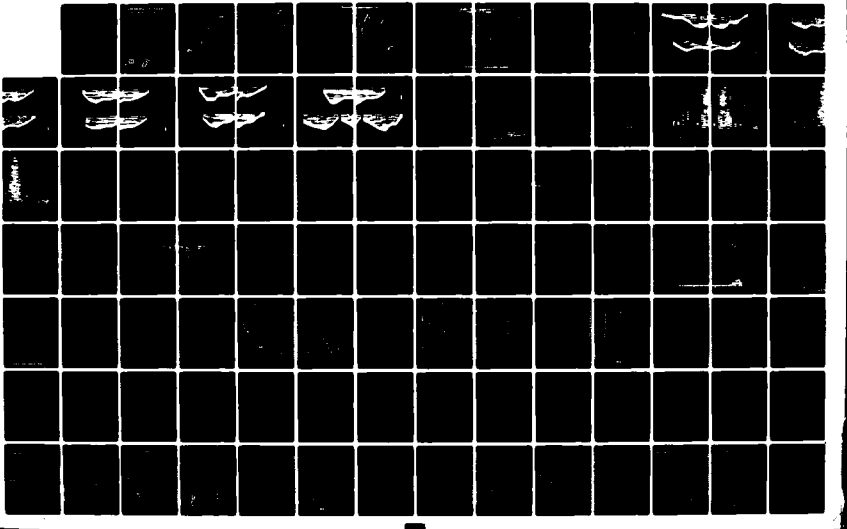
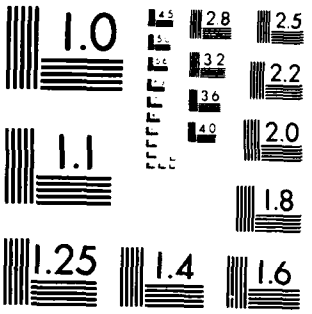
AD-A123 608 EMBANKMENT CRITERIA AND PERFORMANCE REPORT MISSOURI RIVER FORT PECK LAKE MONTANA VOLUME II DRAWINGS(U) ARMY ENGINEER DISTRICT OMAHA NEBR SEP 82 1/2

UNCLASSIFIED F/G 13/13 NL



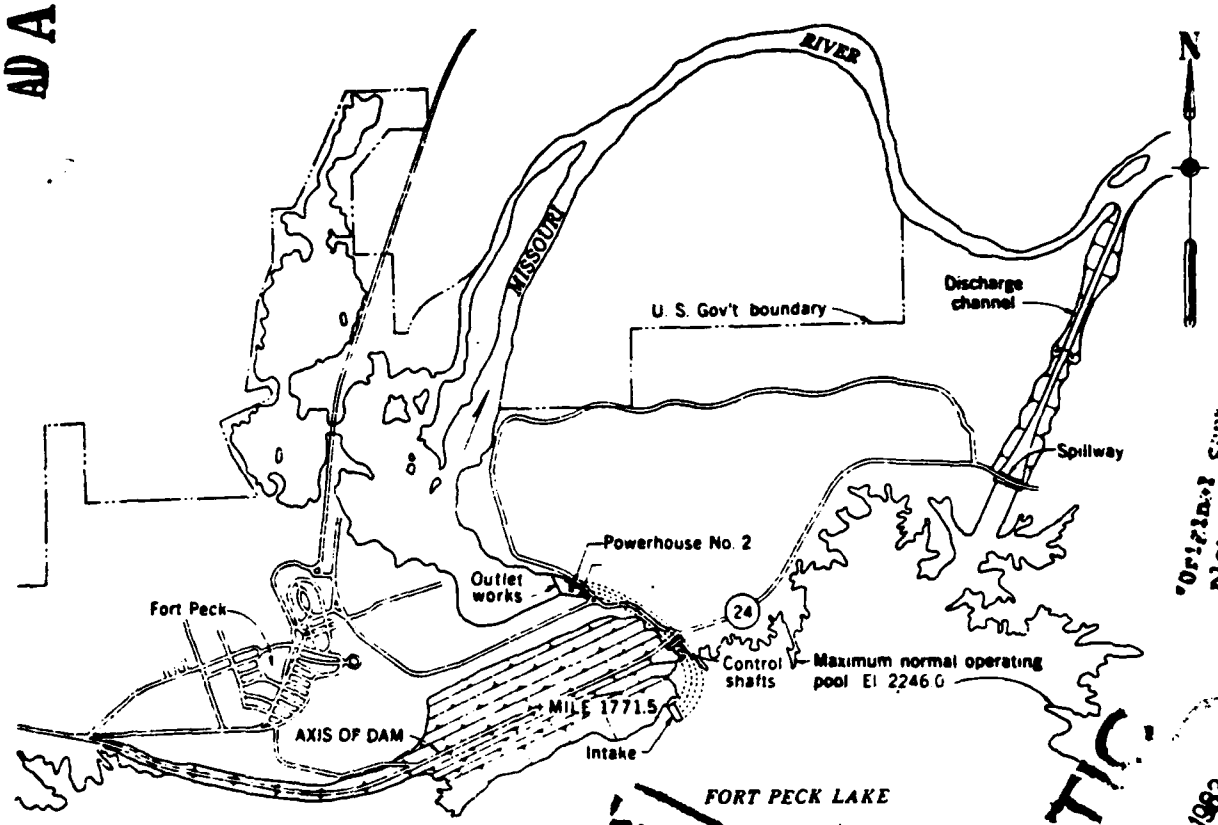


EMBANKMENT CRITERIA AND PERFORMANCE REPORT

(5)

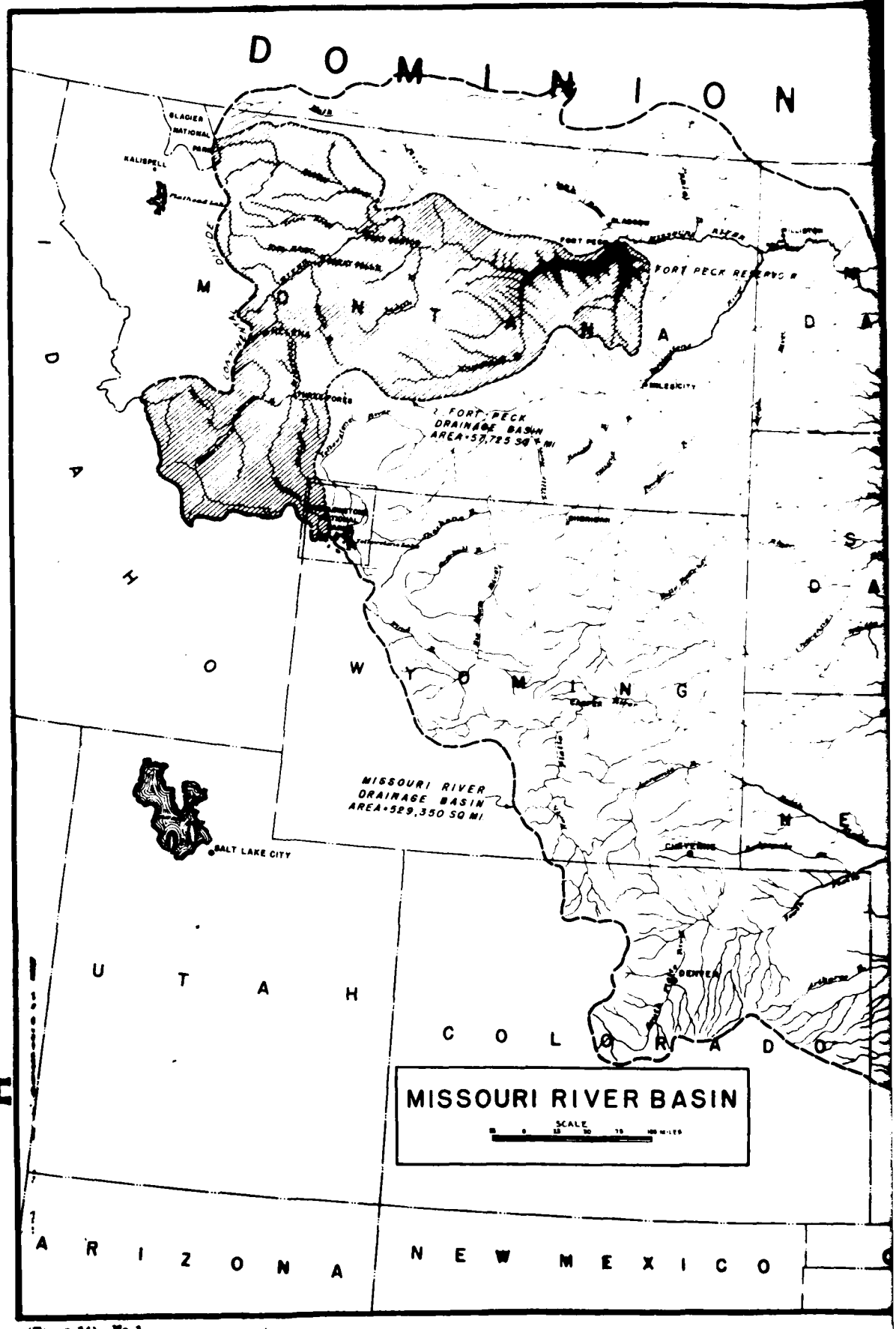
SEPTEMBER 1982

MISSOURI RIVER
FORT PECK LAKE, MONTANA



VOLUME II.
DRAWINGS

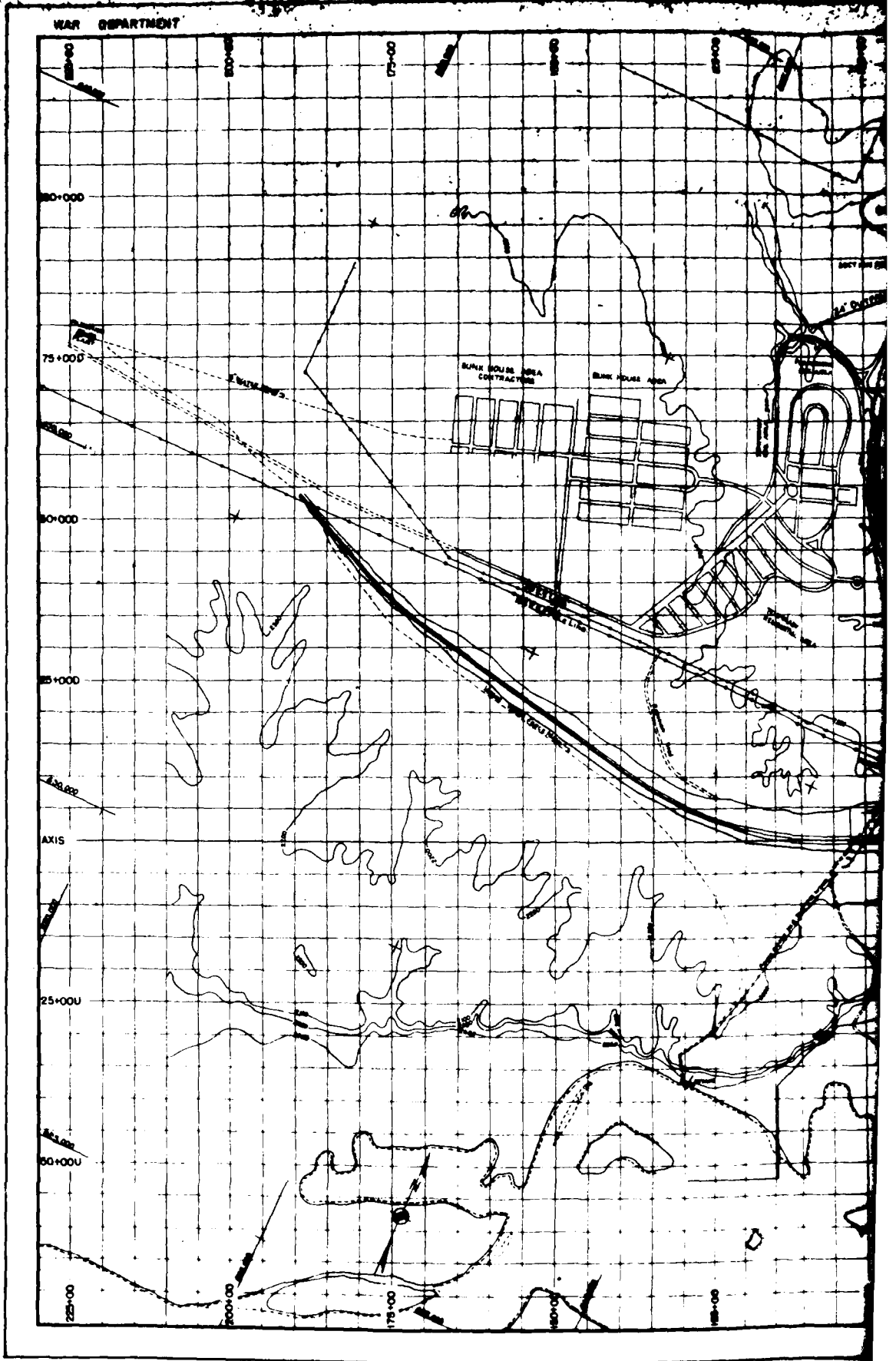
US Army Corps of Engineers
Omaha District

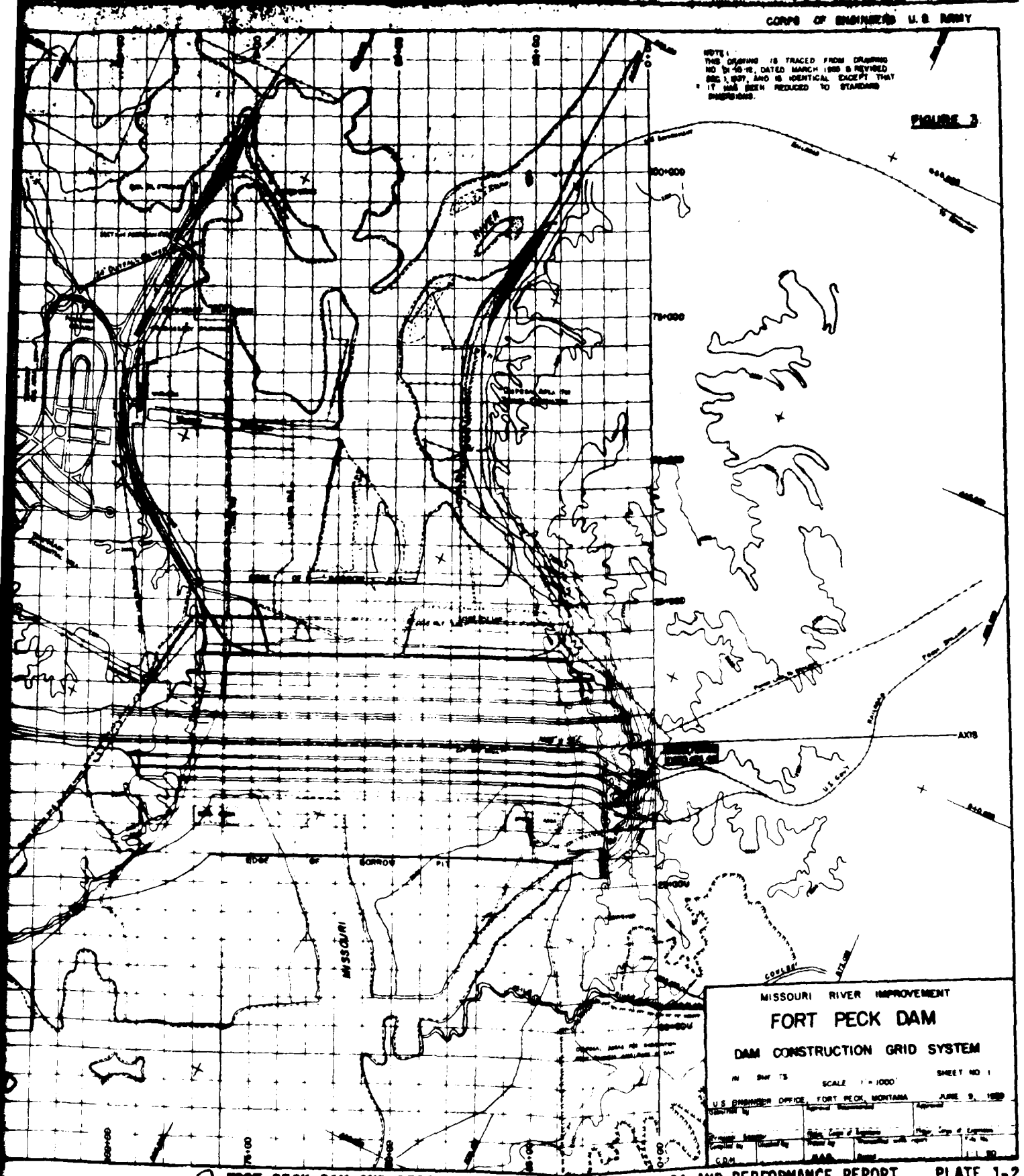


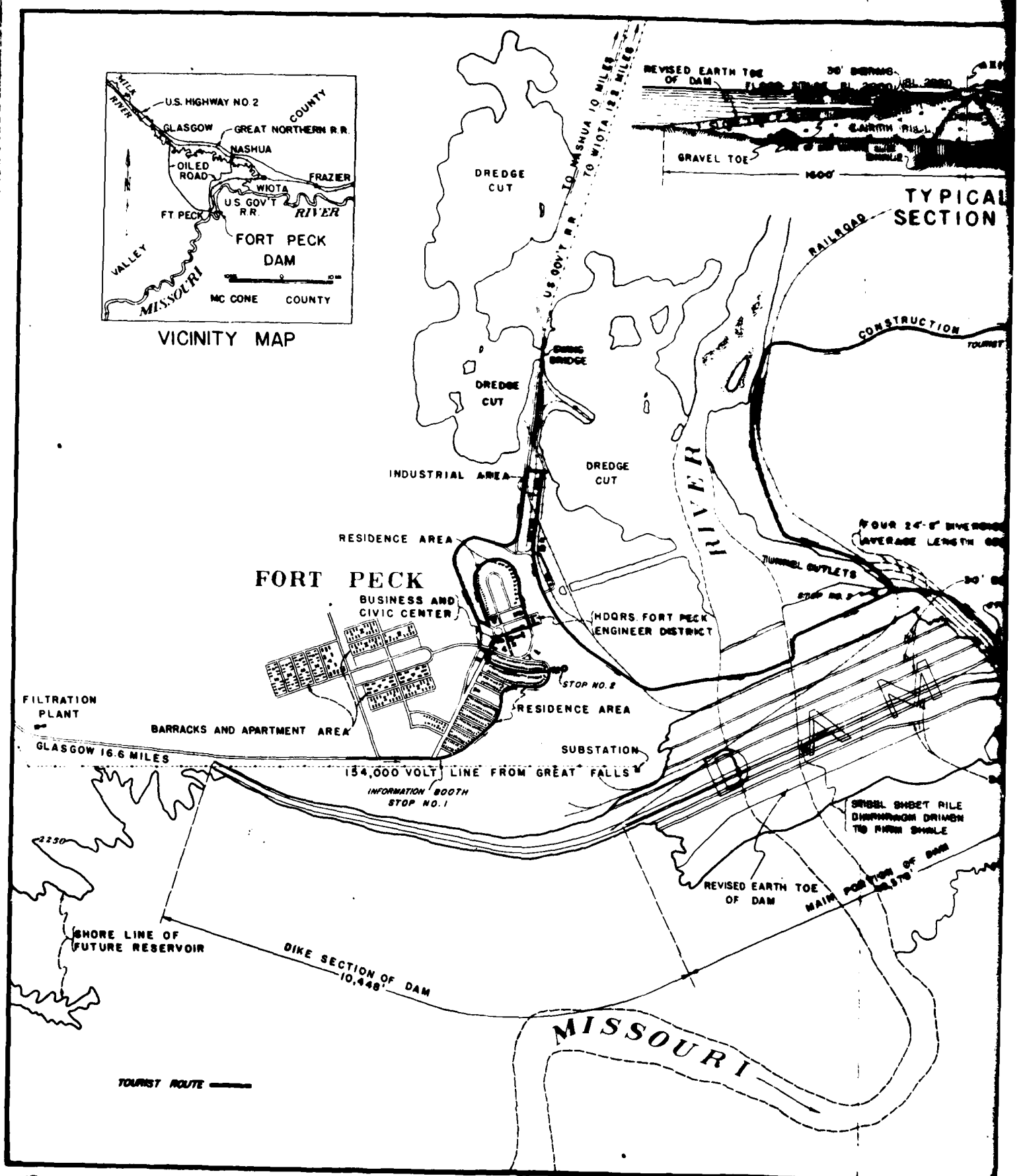
(Page p. 14) No. 1

FORT PECK DAM AND RESERVOIR EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 1-1

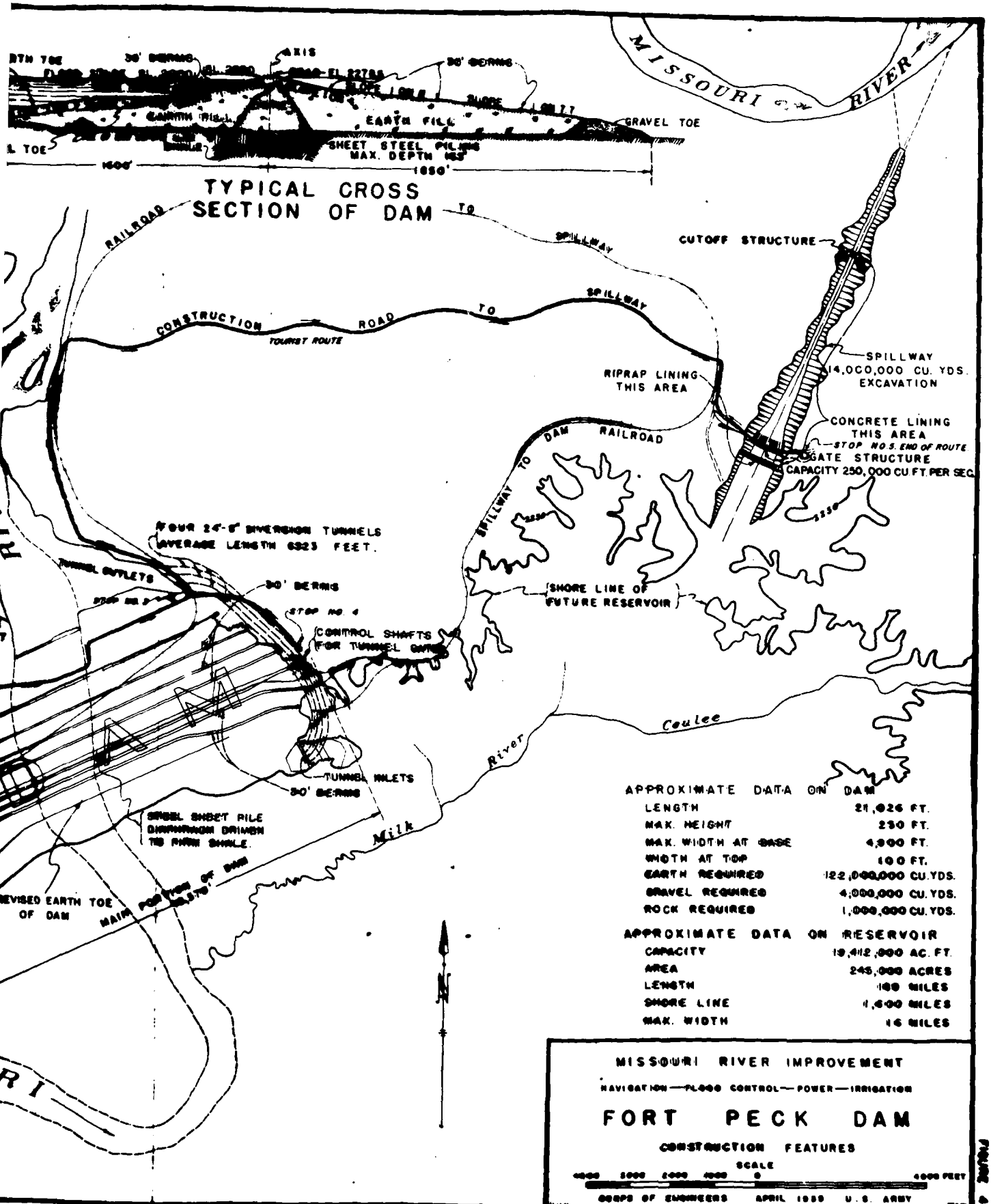
2




CORPS OF ENGINEERS U.S. ARMY
NOTE:
THIS DRAWING IS TRACED FROM DRAWING NO DI-40-16, DATED MARCH 1938 & REVISED DEC 1, 1937, AND IS IDENTICAL EXCEPT THAT IT HAS BEEN REDUCED TO STANDARD DIMENSIONS.
FIGURE 3
AXIS
MISSOURI
MISSOURI RIVER IMPROVEMENT
FORT PECK DAM
DAM CONSTRUCTION GRID SYSTEM
SCALE 1" = 1000'
SHEET NO 1
U.S. ENGINEER OFFICE, FORT PECK, MONTANA
JUNE 9, 1939

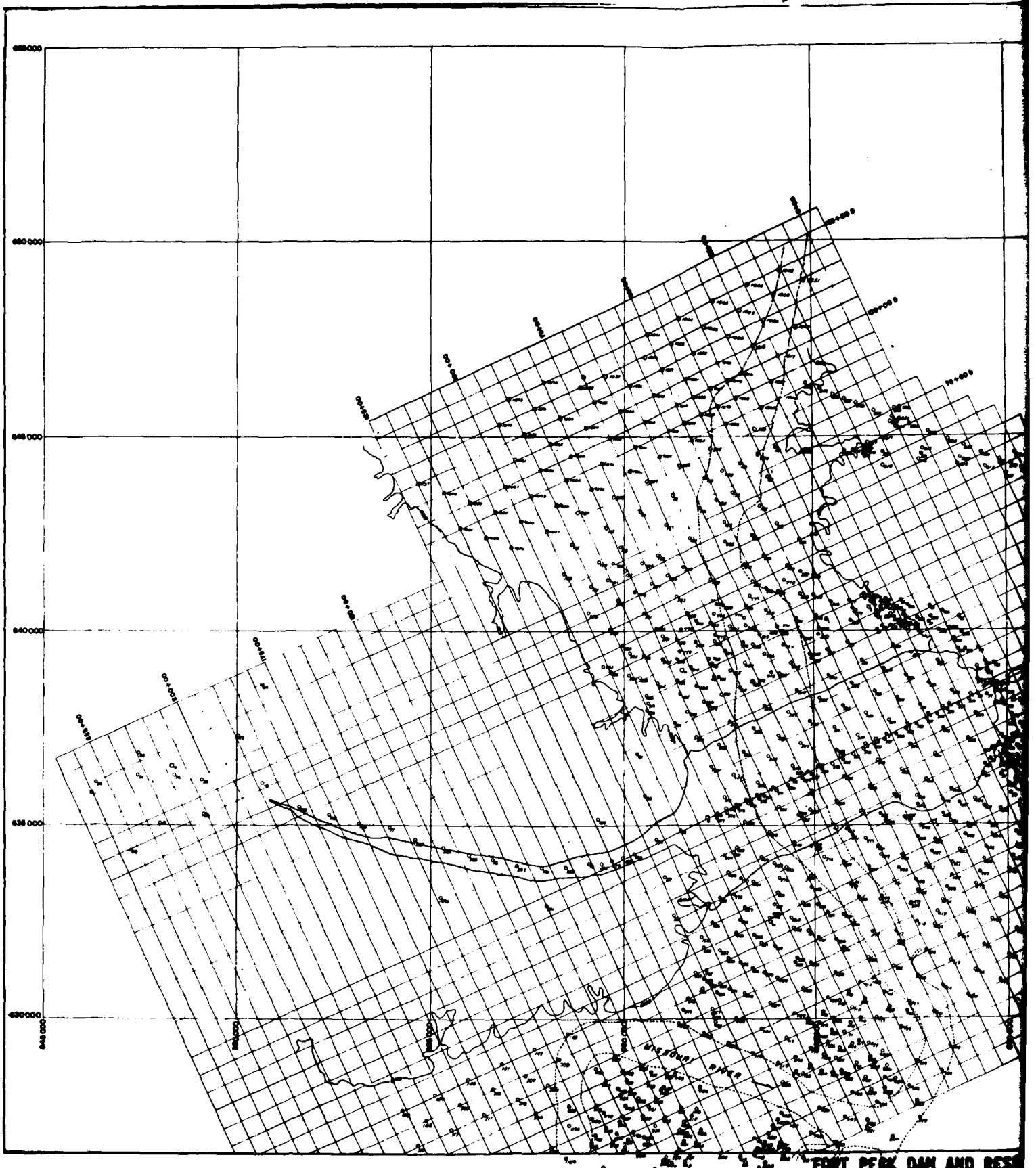


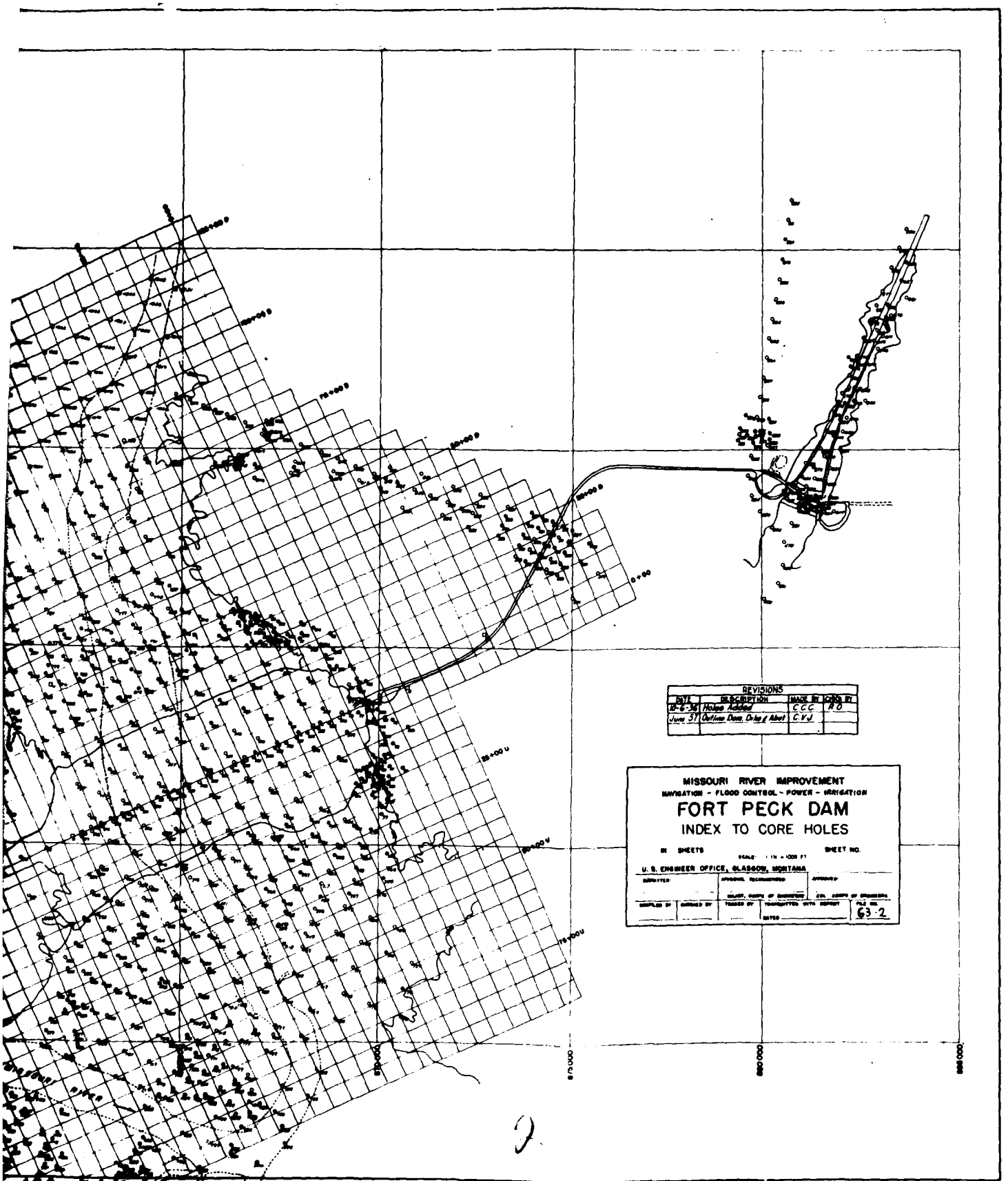
(Place p. 14) No. 3



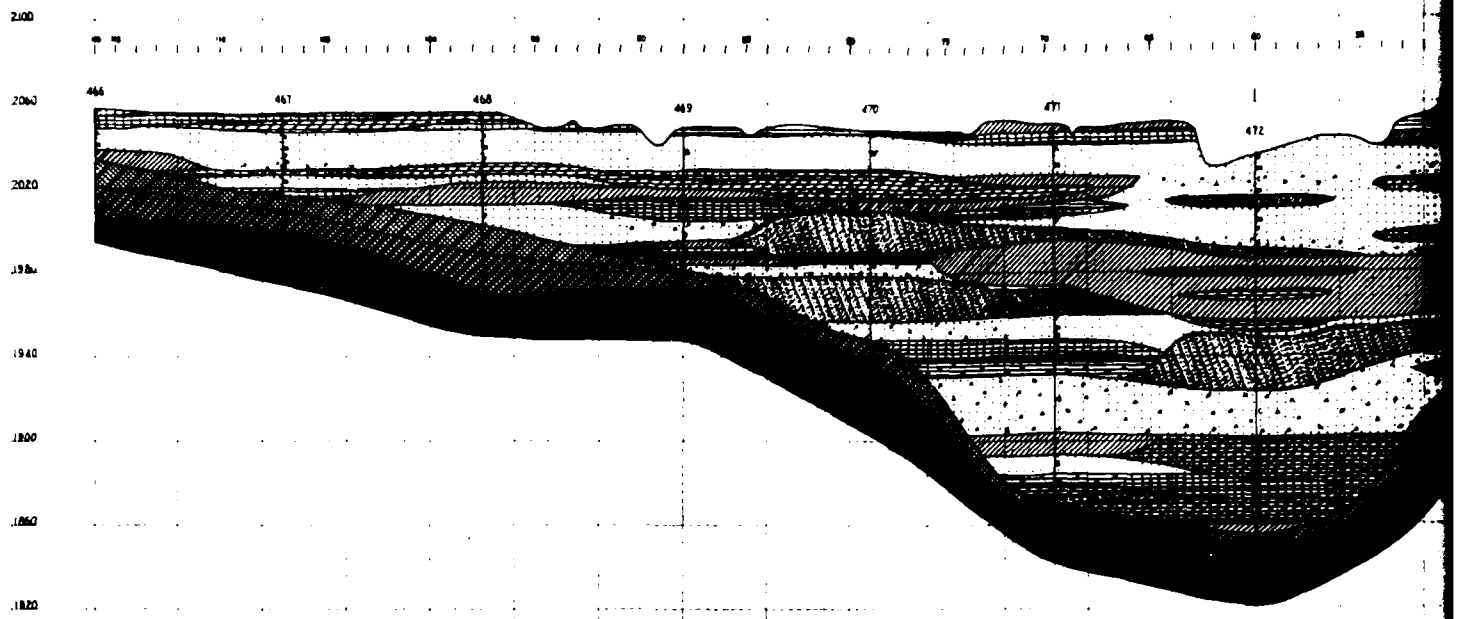
[redacted] AND PERFORMANCE REPORT PLATE 2-1

2

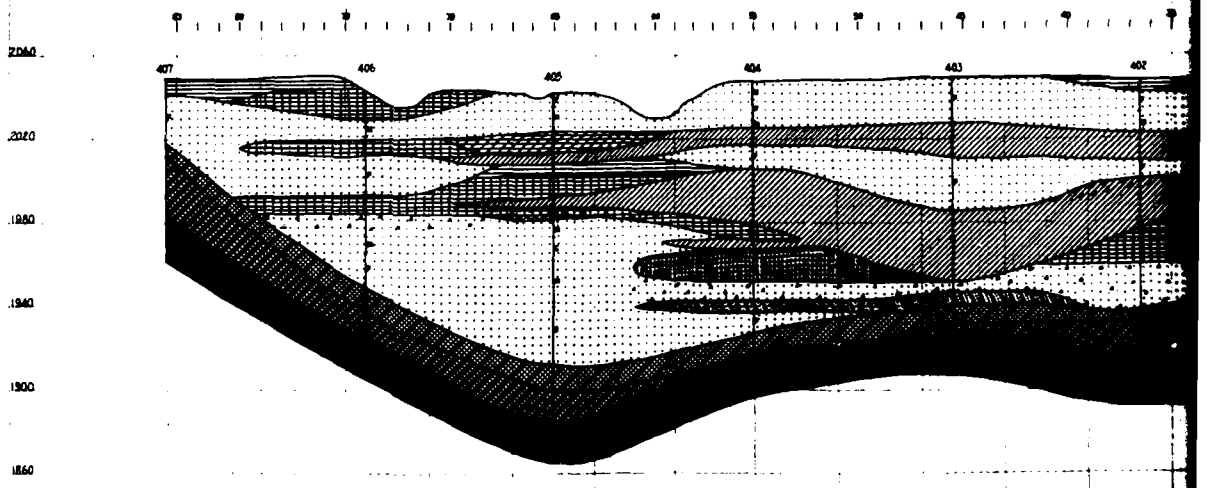

FORT PECK DAM AND RES


REVISIONS
DATE | DESCRIPTION | MADE BY | CHKD BY
10-6-56 | Holes Added | C.C.C. | A.O.
June 57 | Outline Dam, Drks & Abut | C.V.J.
MISSOURI RIVER IMPROVEMENT
NAVIGATION - FLOOD CONTROL - POWER - IRRIGATION
FORT PECK DAM
INDEX TO CORE HOLES
SHEETS
SHEET NO.
U. S. ENGINEER OFFICE, GLASGOW, MONTANA
63-2

WAR DEPARTMENT

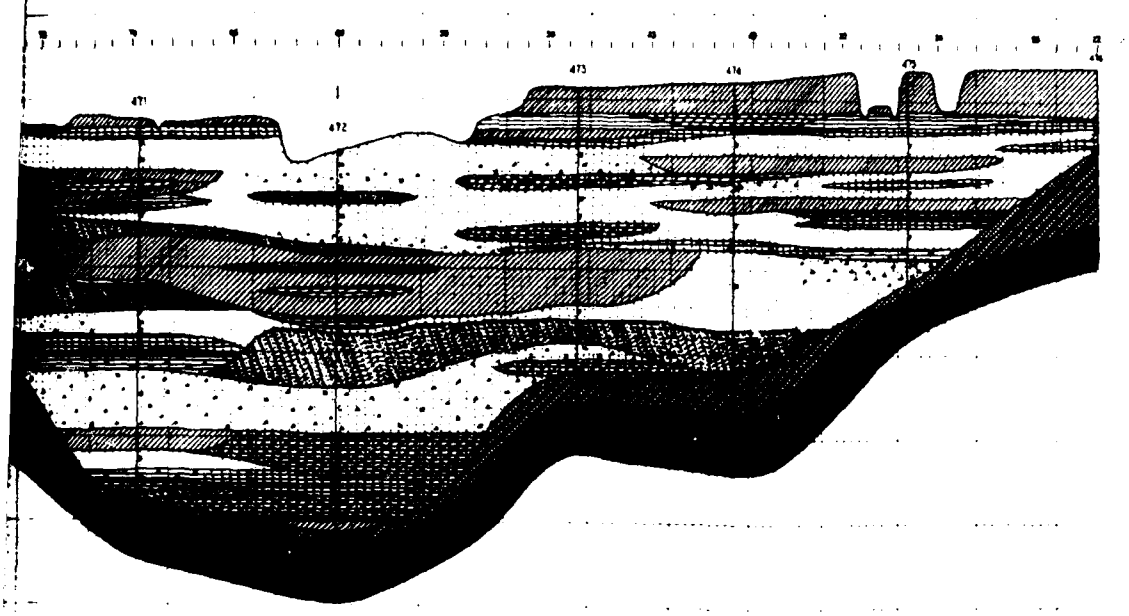


LINE 44+00-U



LINE 9+40-U

FORT PECK DAM AND RES



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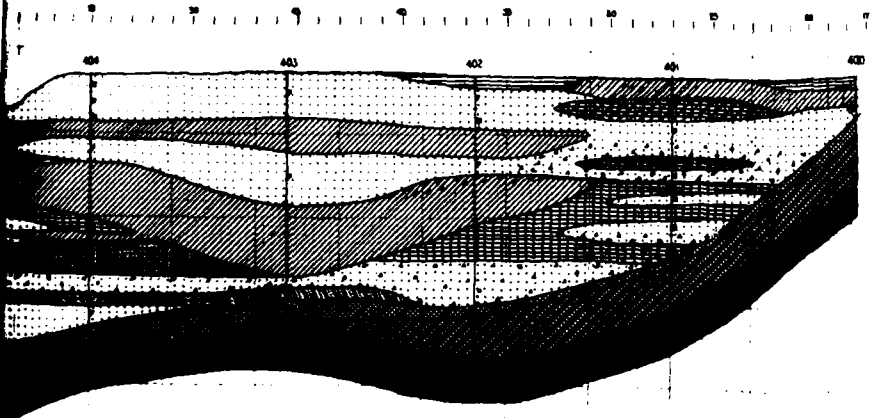


LINE 9+40-U

LEGEND

BUREAU OF SOILS CLASSIFICATION

- SAND
- GRAVELLY SAND
- LOAM
- SANDY LOAM
- GRAVELLY LOAM
- SANDY GRAVELLY LOAM
- CLAY
- GRAVELLY CLAY
- CLAY LOAM
- SANDY CLAY LOAM
- GRAVELLY CLAY LOAM
- SANDY GRAVELLY CLAY LOAM
- GRAVEL
- SANDY GRAVEL
- SOFT SHALE
- SUB-FIRM SHALE
- FIRM SHALE

MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

FOUNDATION SOIL PROFILES

IN SHEETS SCALE VERT 1" = 400' HOR 1" = 40' SHEET NO 1

U S ENGINEER OFFICE MISSOURI RIVER DIVISION

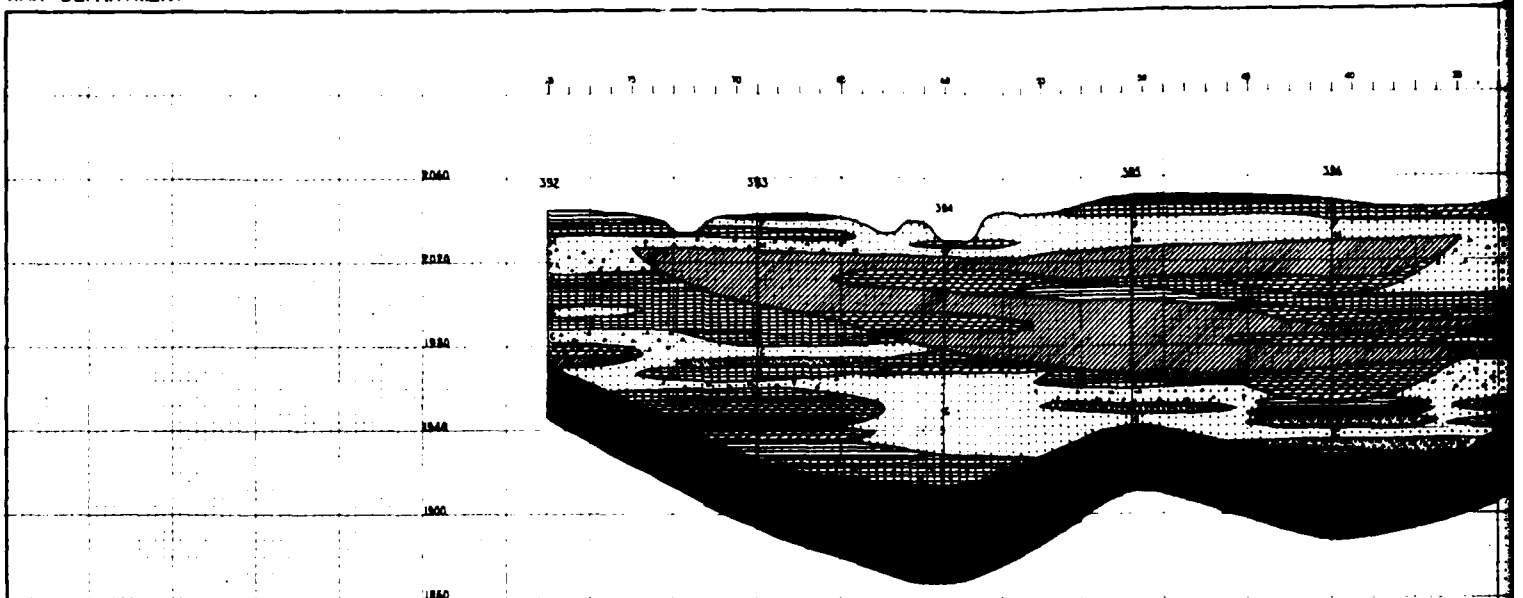
FORT PECK MONTANA FEB. 1938

Submitted	Recommended	Approved
Associate Engineer	Senior Engineer	Major Corps of Engineers

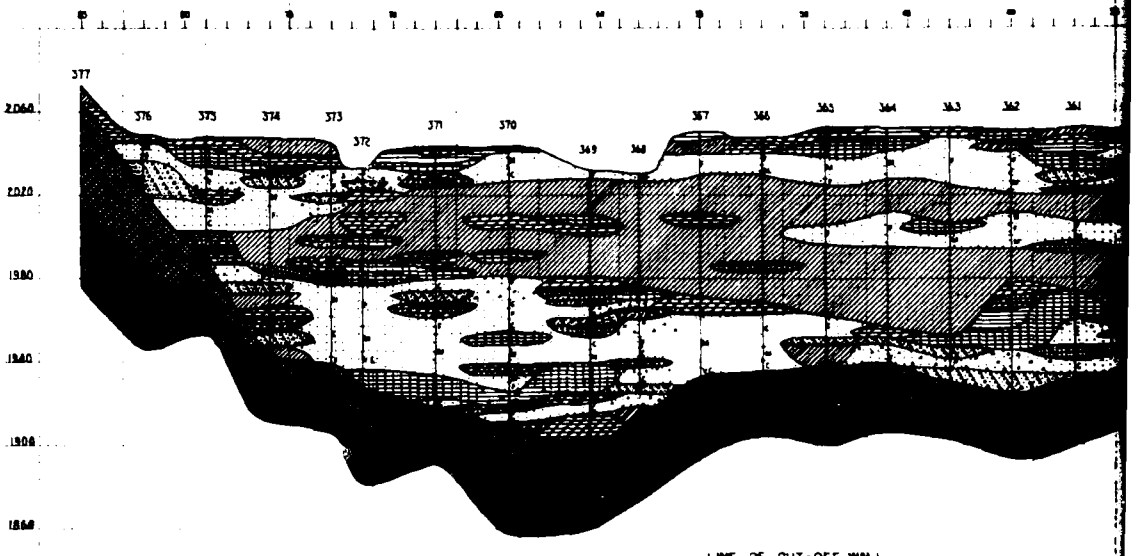
Drawn	Traced	Checked	Transmitted	File
CAL	CAL			3.3-11-2

FORT PECK DAM AND RESERVOIR EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 3-2

WAR DEPARTMENT

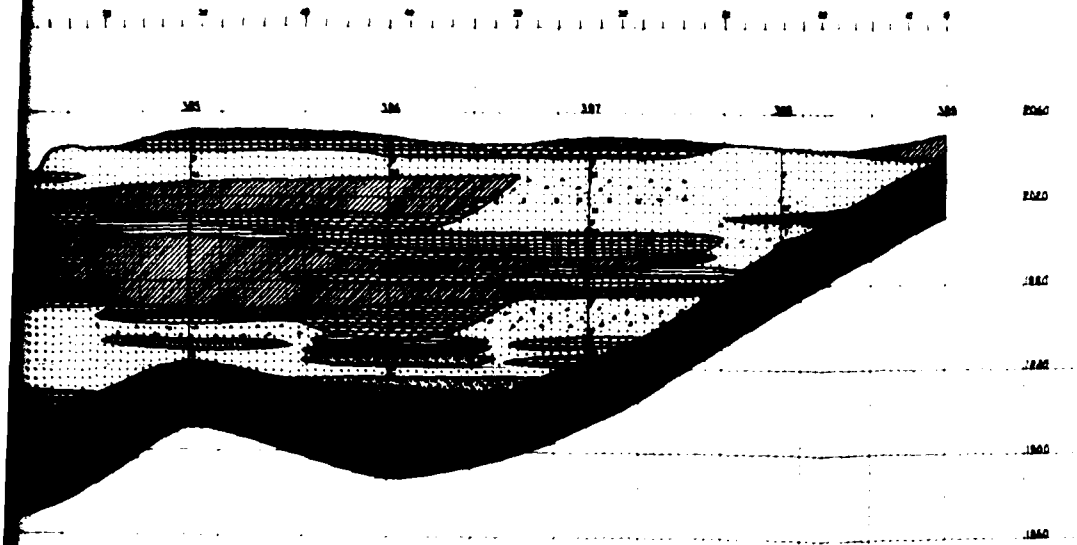


LINE 4+50 - U

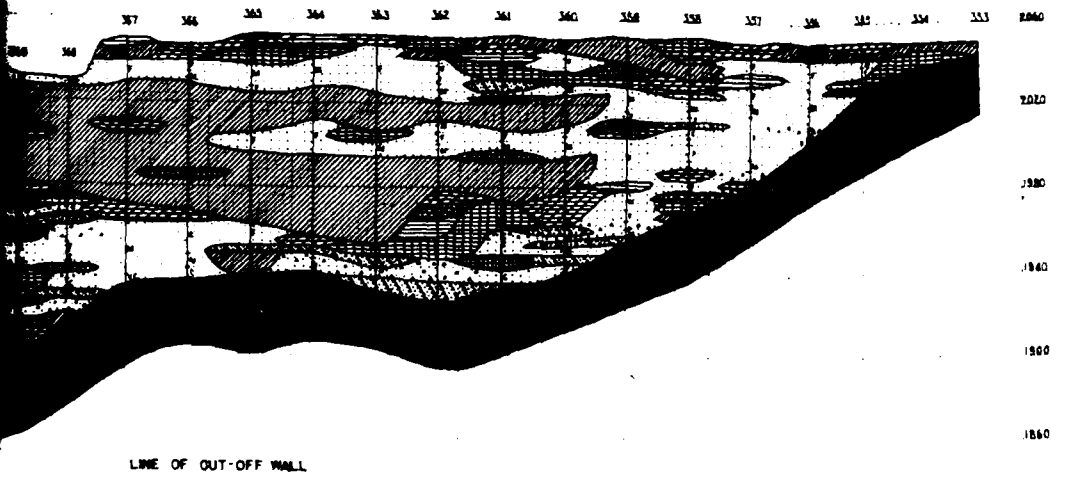


LINE OF CUT-OFF WALL

FORT PECK DAM AND RE



LINE 4+50 - U



LINE OF CUT-OFF WALL

LEGEND
BUREAU OF SOILS CLASSIFICATION

- SAND
- GRAVELLY SAND
- LOAM
- SANDY LOAM
- GRAVELLY LOAM
- SANDY GRAVELLY LOAM
- CLAY
- SANDY CLAY
- CLAY LOAM
- GRAVELLY CLAY LOAM
- SANDY CLAY LOAM
- SANDY GRAVELLY CLAY LOAM
- GRAVEL
- SANDY GRAVEL
- WEATHERED SHALE
- SOFT SHALE
- SUB-FIRM SHALE
- FIRM SHALE

MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

FOUNDATION SOIL PROFILES

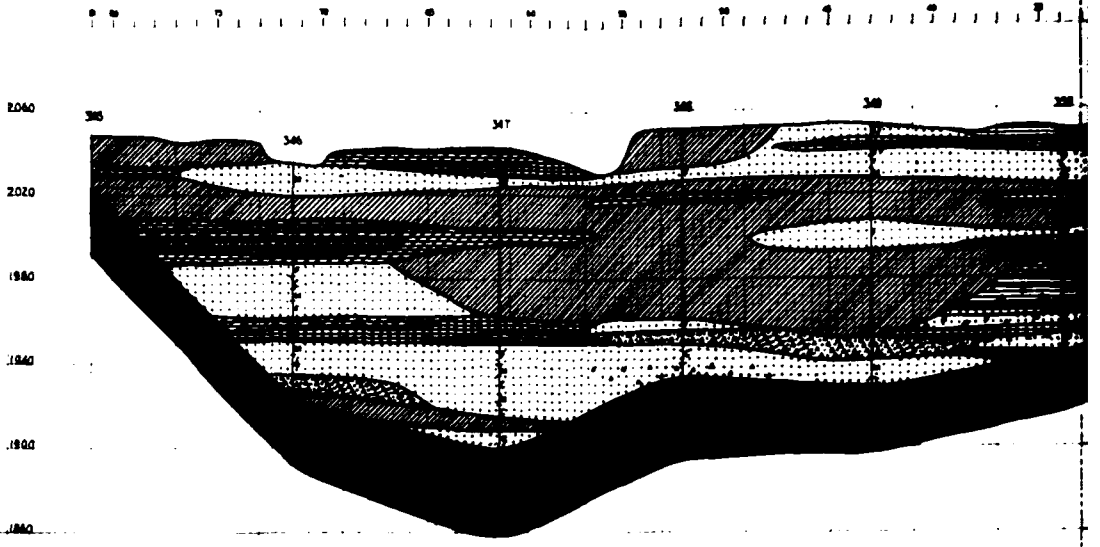
IN SHEETS SCALE: SHEET NO 2

U S ENGINEER OFFICE, MISSOURI RIVER DIVISION,
FORT PECK, MONTANA FEB 1935

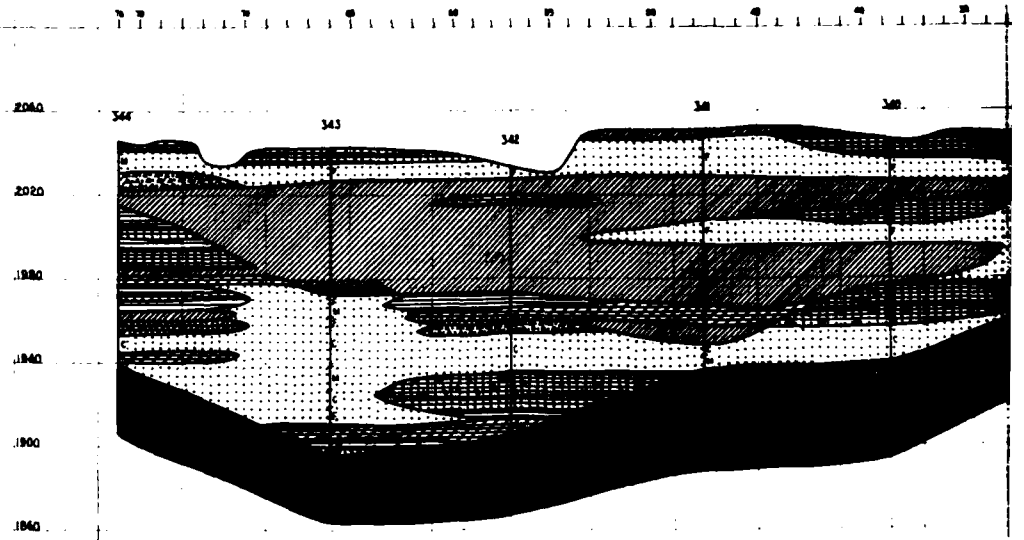
Submitted | Recommended | Approved

Assistant Engineer | Senior Engineer | Chief Corps of Engineers

Drawn | Traced | Checked | Transmitted | File 331.12



LINE 5+50-D



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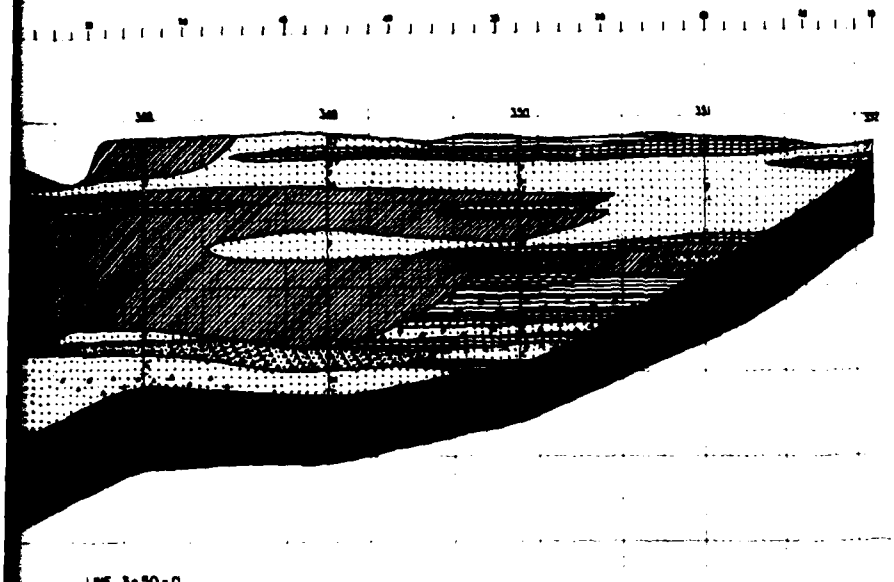

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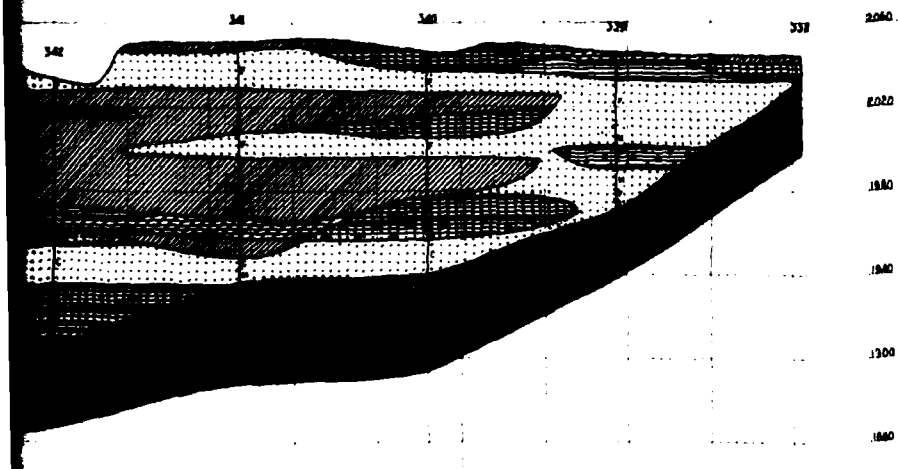


LINE 7+80-D

LEGEND

BUREAU OF SOILS CLASSIFICATION

- SAND
- GRAVELLY SAND
- LOAM
- SANDY LOAM
- GRAVELLY LOAM
- SANDY GRAVELLY LOAM
- CLAY
- SANDY CLAY
- CLAY LOAM
- SANDY CLAY LOAM
- GRAVELLY CLAY LOAM
- SANDY GRAVELLY CLAY LOAM
- SANDY GRAVEL
- WEATHERED SHALE
- SOFT SHALE
- SUB-FIRM SHALE
- FIRM SHALE

MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

FOUNDATION SOIL PROFILES

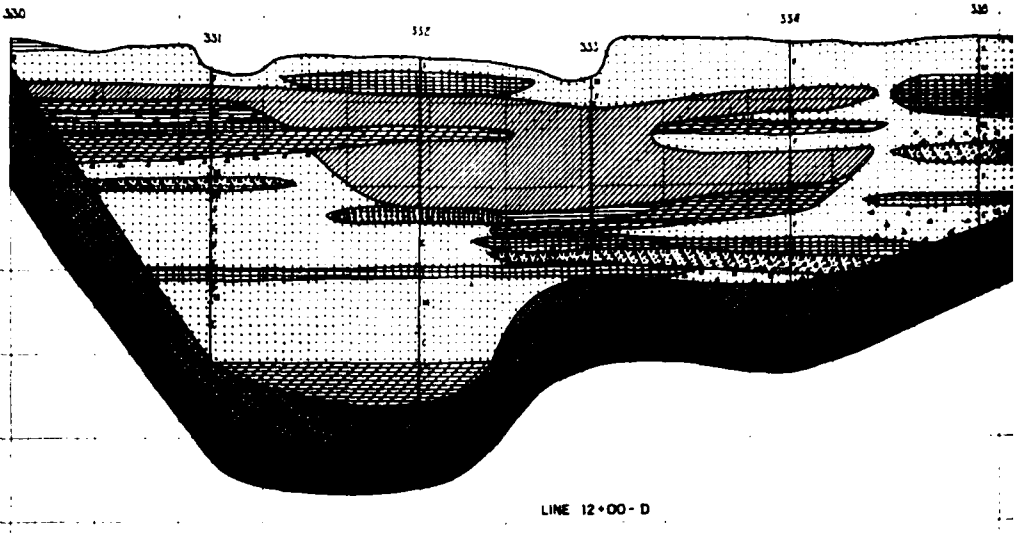
IN SHEETS SCALE SHEET NO 3

U S ENGINEER OFFICE, MISSOURI RIVER DIVISION,
FORT PECK, MONTANA FEB 1938

Submitted | Recommended | Approved

Assistant Engineer | Senior Engineer | Major Corps of Engineers

Drawn | Traced | Checked | Transmitted | File 33-11-2



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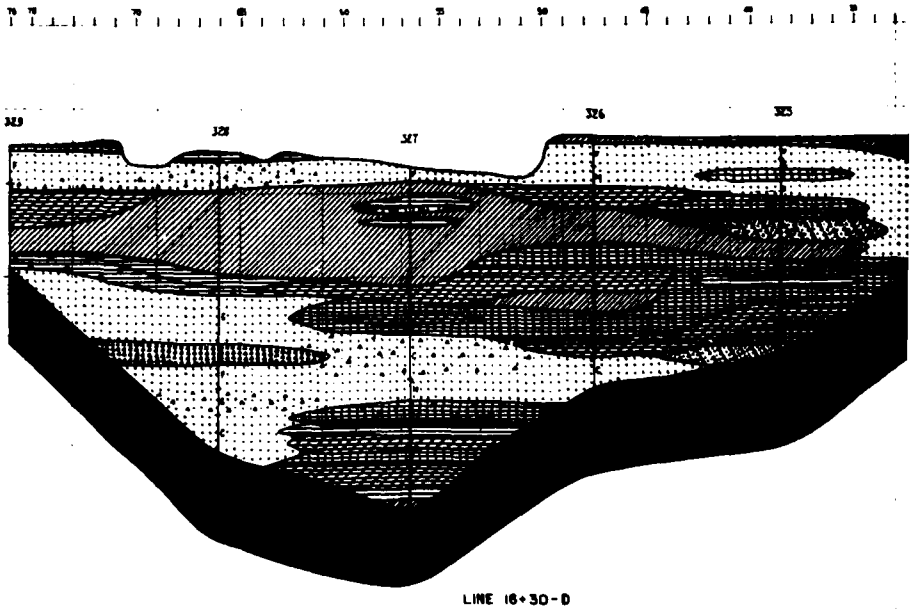

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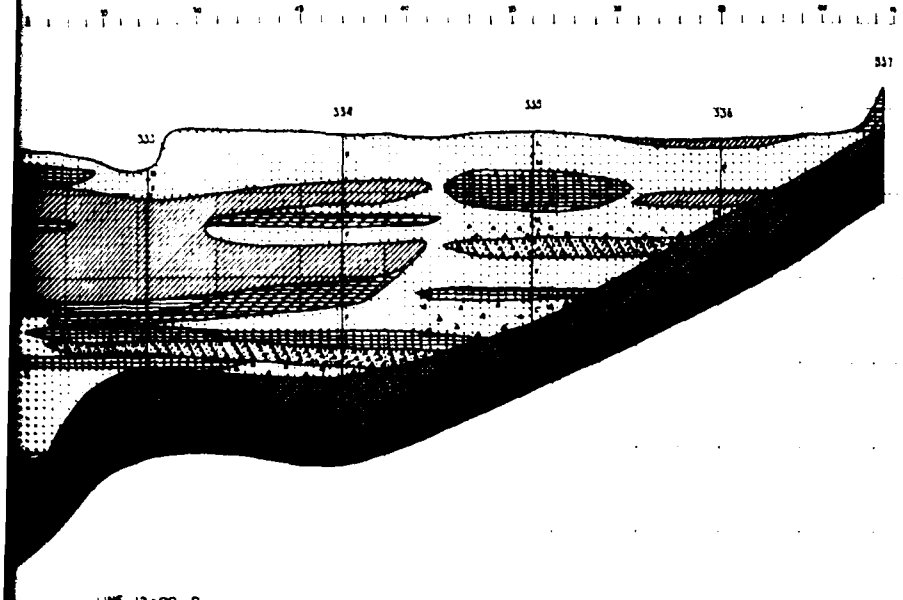
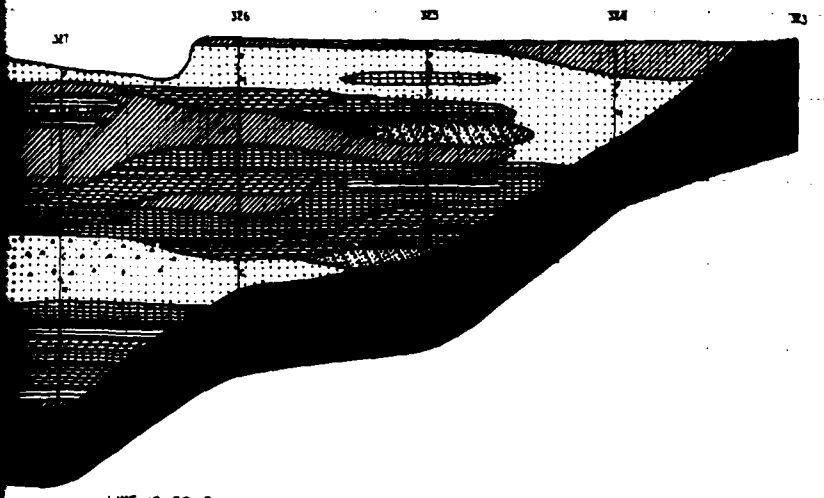


LINE 12+00 - D



LINE 18+30 - D

LEGEND

BUREAU OF SOILS CLASSIFICATION

- SAND
- GRAVELLY SAND
- LOAM
- SANDY LOAM
- GRAVELLY LOAM
- SANDY GRAVELLY LOAM
- CLAY
- CLAY LOAM
- GRAVEL
- SANDY GRAVEL
- WEATHERED SHALE
- SOFT SHALE
- SUB-FIRM SHALE
- FIRM SHALE

MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

FOUNDATION SOIL PROFILES

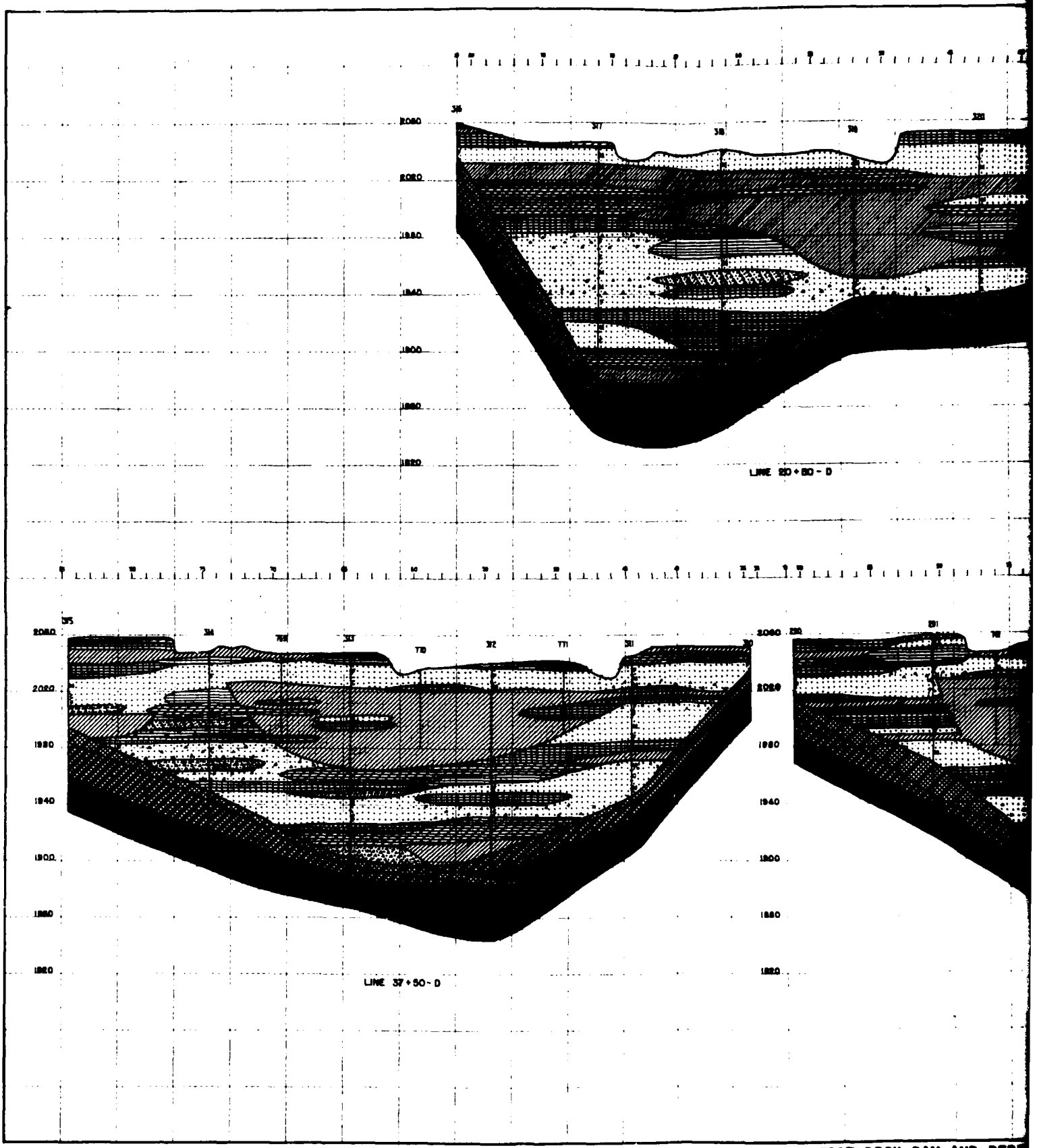
IN SHEETS SCALE SHEET NO 4

U S ENGINEER OFFICE, MISSOURI RIVER DIVISION

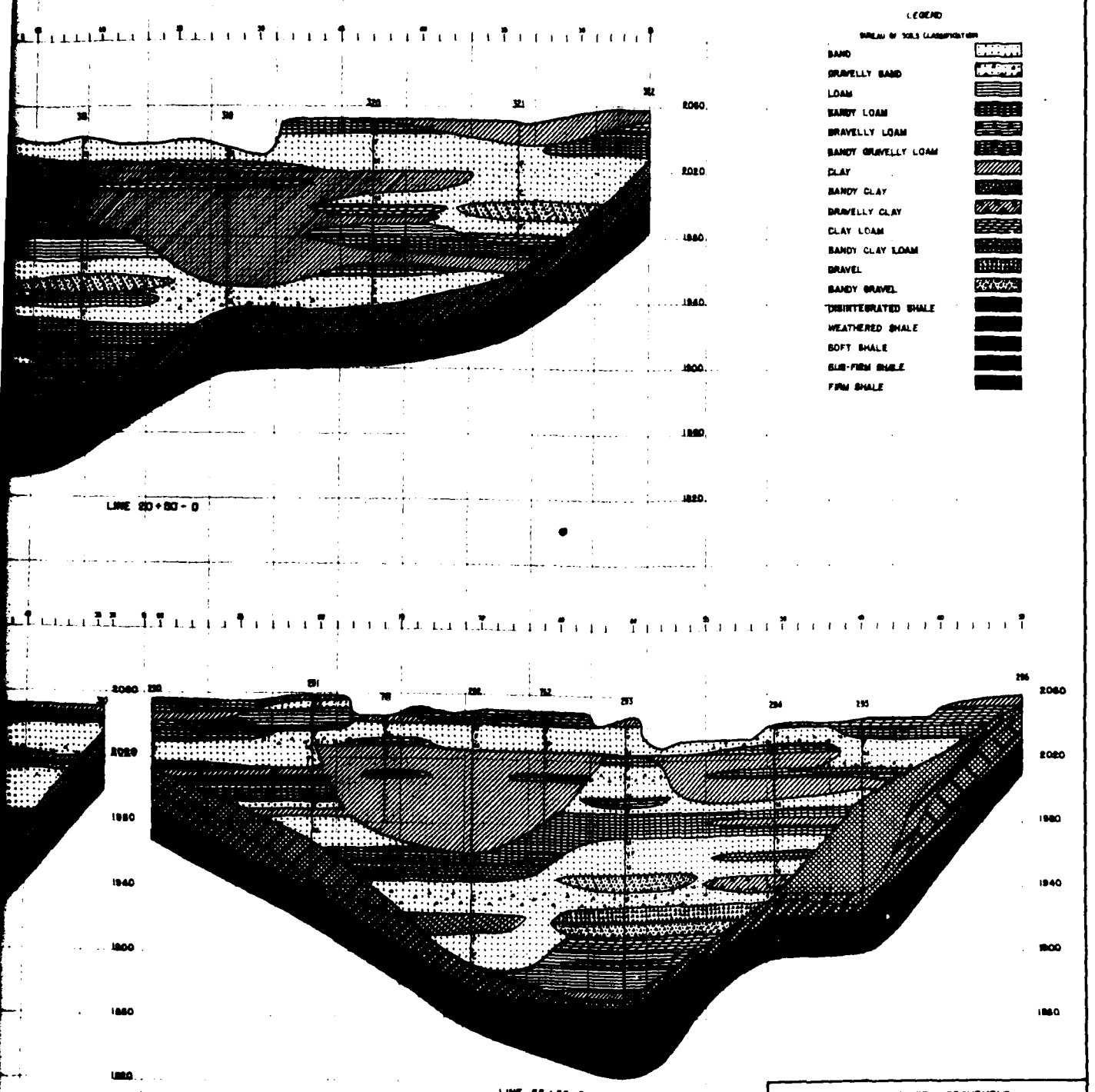
FORT PECK, MONTANA MARCH 1938

Submitted	Recommended	Approved
Associate Engineer	Senior Engineer	Major Corps of Engineers

Drawn	Traced	Checked	Transmitted	File
				33-11-Z



FORT PECK DAM AND RESE



MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

FOUNDATION SOIL PROFILES

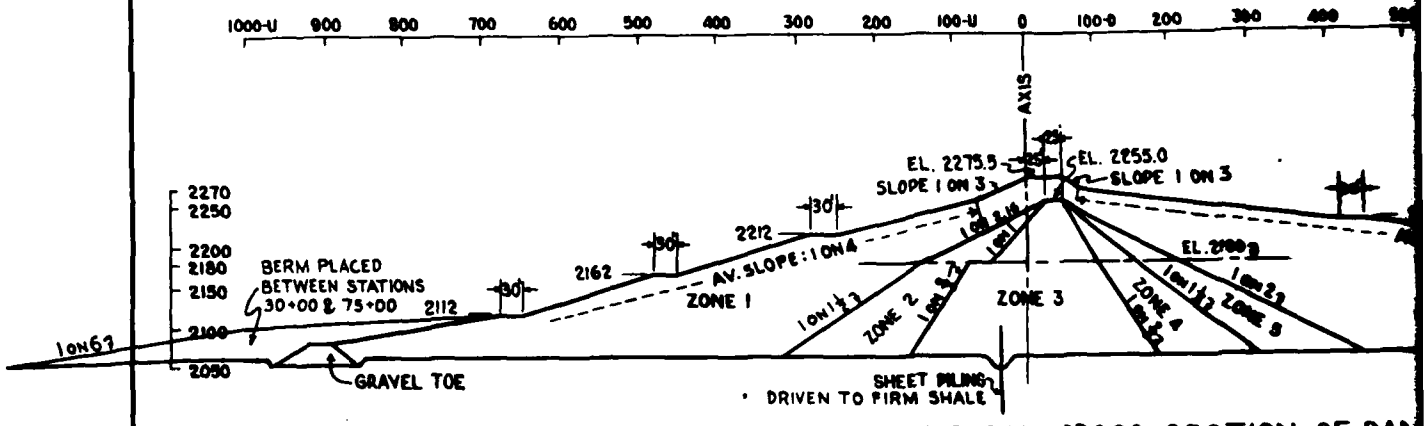
IN SHEETS SCALE HOR 1"=400' VERT 1"=40' SHEET NO 5

U S ENGINEER OFFICE, FORT PECK, MONTANA — MISSOURI RIVER DIVISION, MARCH 1938.

Submitted | Recommended | Approved

Drawn | Traced | Checked | Transmitted | File 33-41-Z

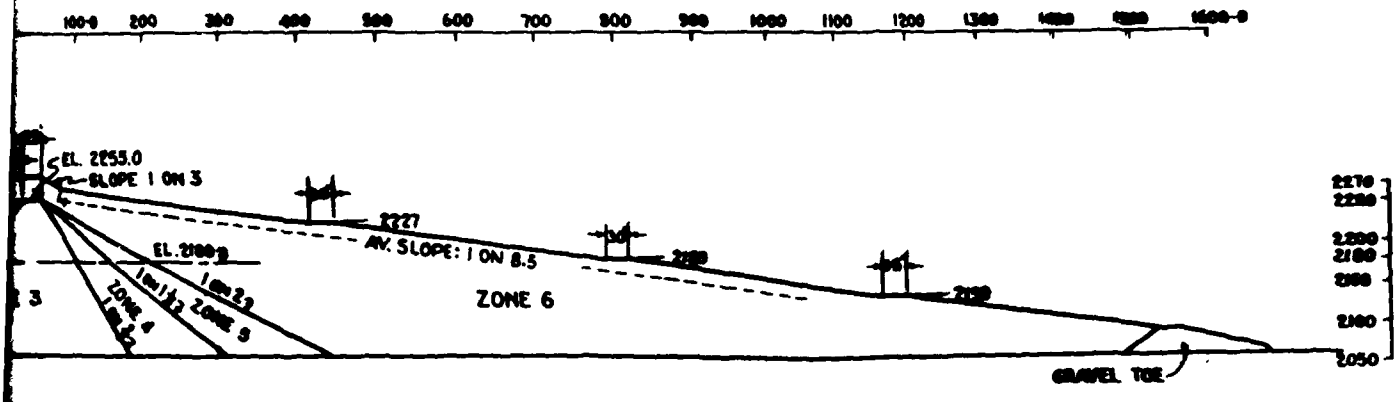
WAR DEPARTMENT



TYPICAL CROSS SECTION OF DAM

ZONE	ELEVATION	AVERAGE EFFECTIVE SIZE IN MILLIMETERS	AVERAGE CLAY CONTENT PER CENT
1 and 6	Below 2100	>0.1	<3.0
1 and 6	2100-2180	>0.1	<5.0
1 and 6	Above 2180	>0.05	<8.0
2 and 5	Below 2255	>0.005	<10.0
3	Below 2200	<0.005	>10.0 & <30.0
3	Above 2200	<0.01	<30.0
4	Below 2255	Same as Zone 3 or Zone 5	
Sand Plugs	Below 2180	<0.10	<20.0
Above Sand Plugs	2180-2255	<0.01	<30.0

(Face p. 14) No. 5



CROSS SECTION OF DAM

REVISED 3-31-38. F.K.N. REVISED 8-31-38. R.A.W.

MISSOURI RIVER IMPROVEMENT

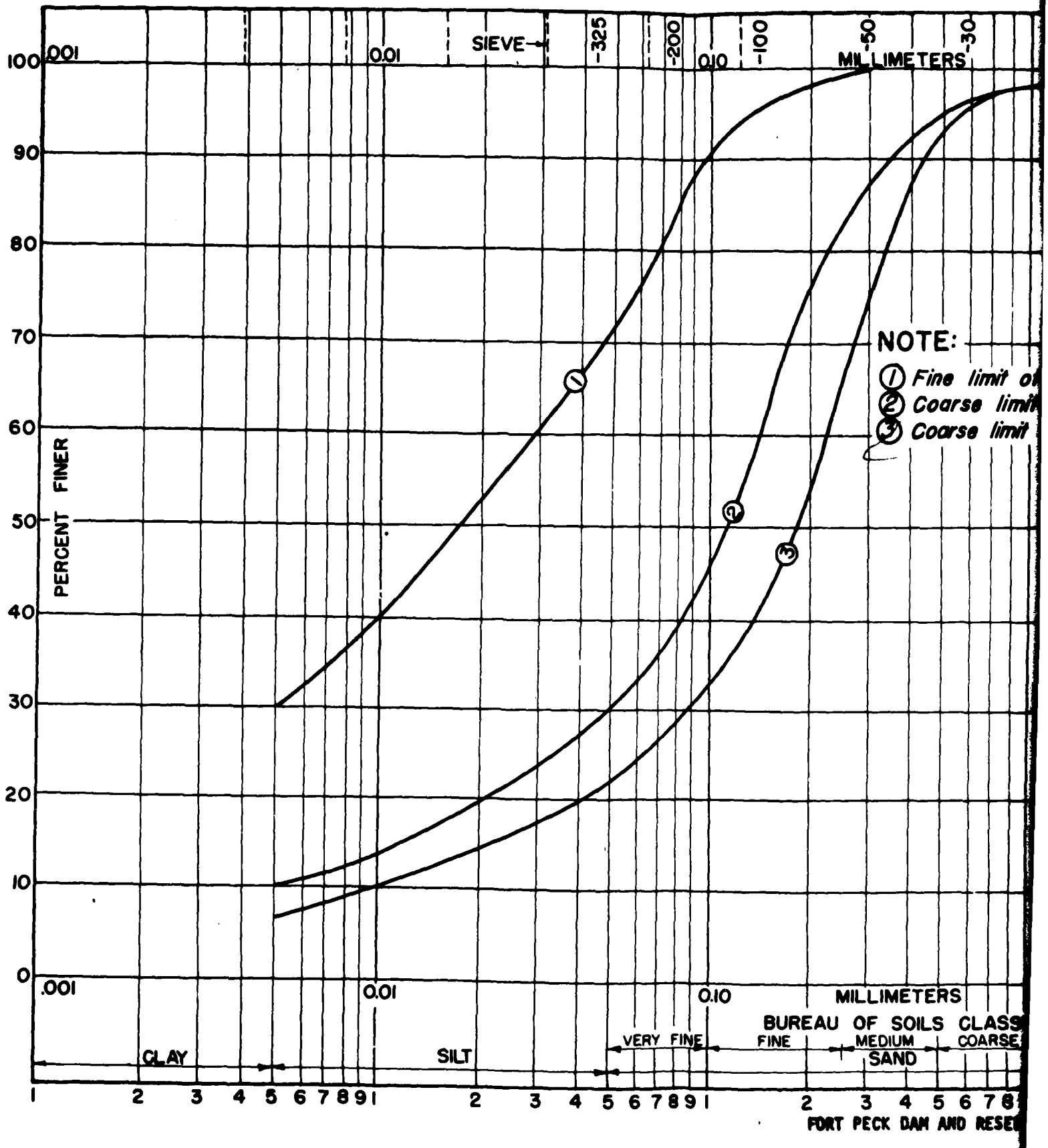
FORT PECK DAM
SPECIFICATIONS

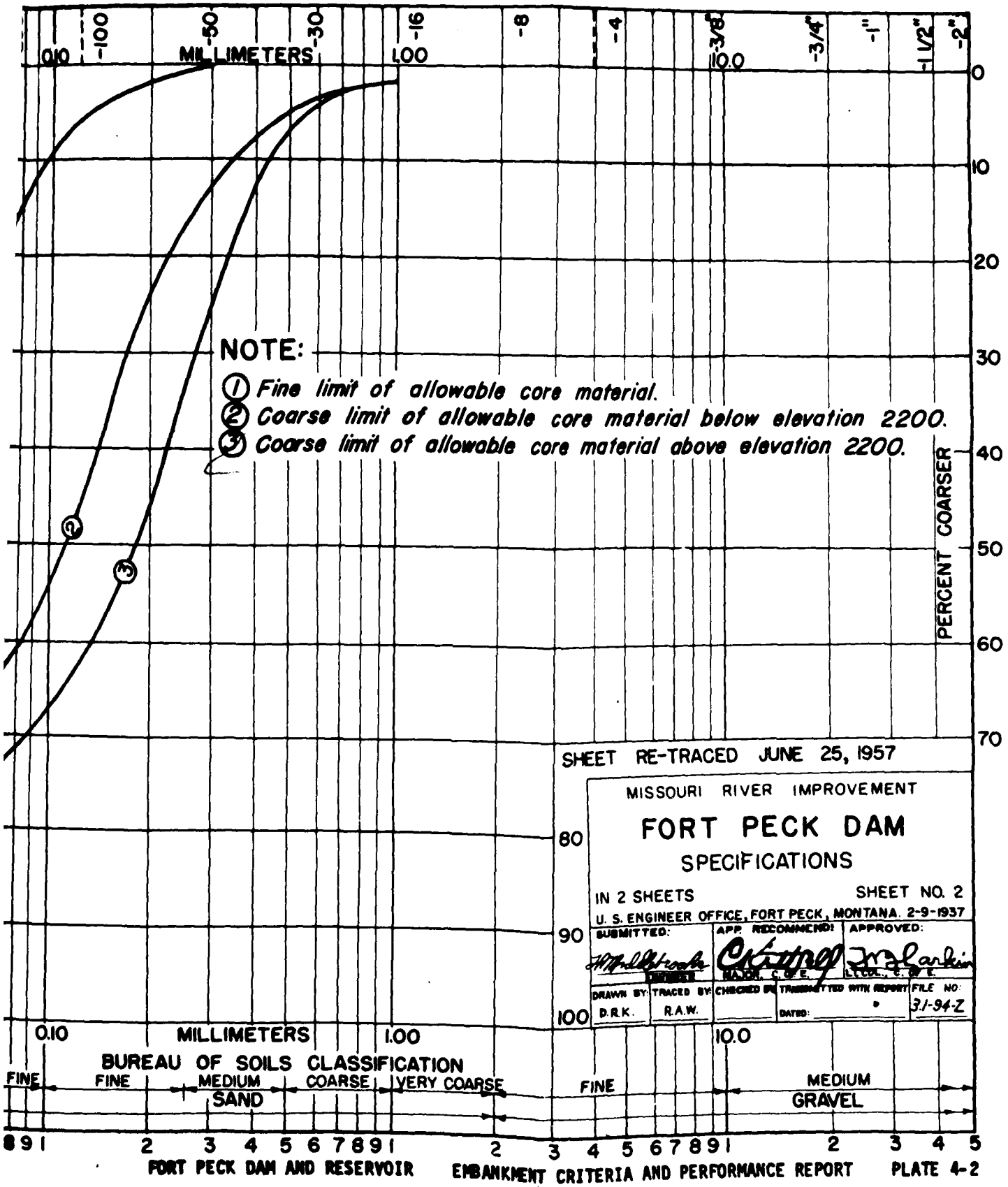
IN 2 SHEETS SCALE AS SHOWN SHEET NO. 1

U.S. ENGINEER OFFICE, FORT PECK, MONT., 2-9-1937

Figure 6

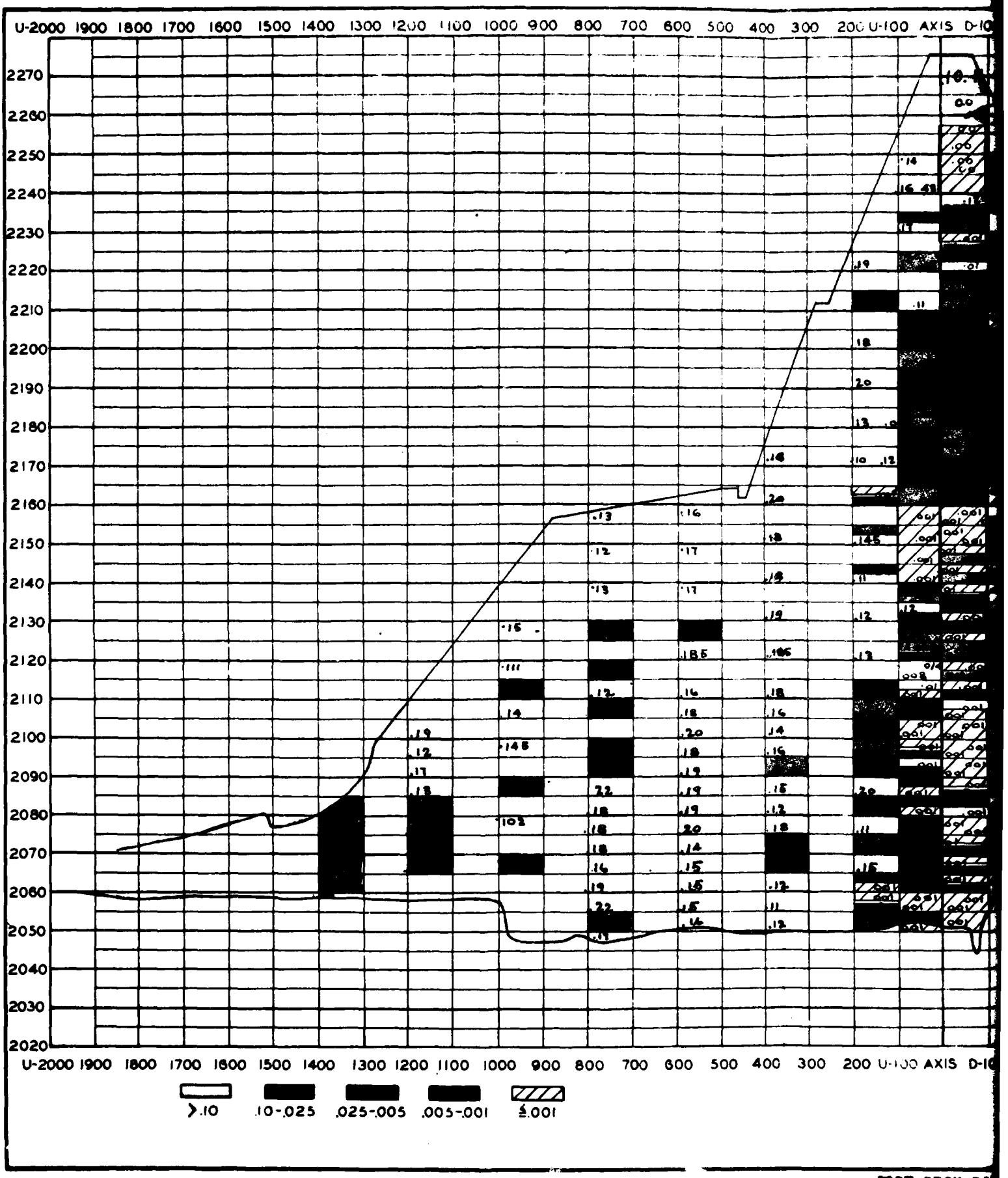
2


SIEVE
-325
-200
-100
-50
-30
.001
0.01
0.10
MILLIMETERS
PERCENT FINER
100
90
80
70
60
50
40
30
20
10
0
NOTE:
(1) Fine limit of
(2) Coarse limit
(3) Coarse limit
.001
0.01
0.10
MILLIMETERS
BUREAU OF SOILS CLASS
CLAY
SILT
VERY FINE
FINE
MEDIUM
COARSE
SAND
1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8
FORT PECK DAM AND RESE

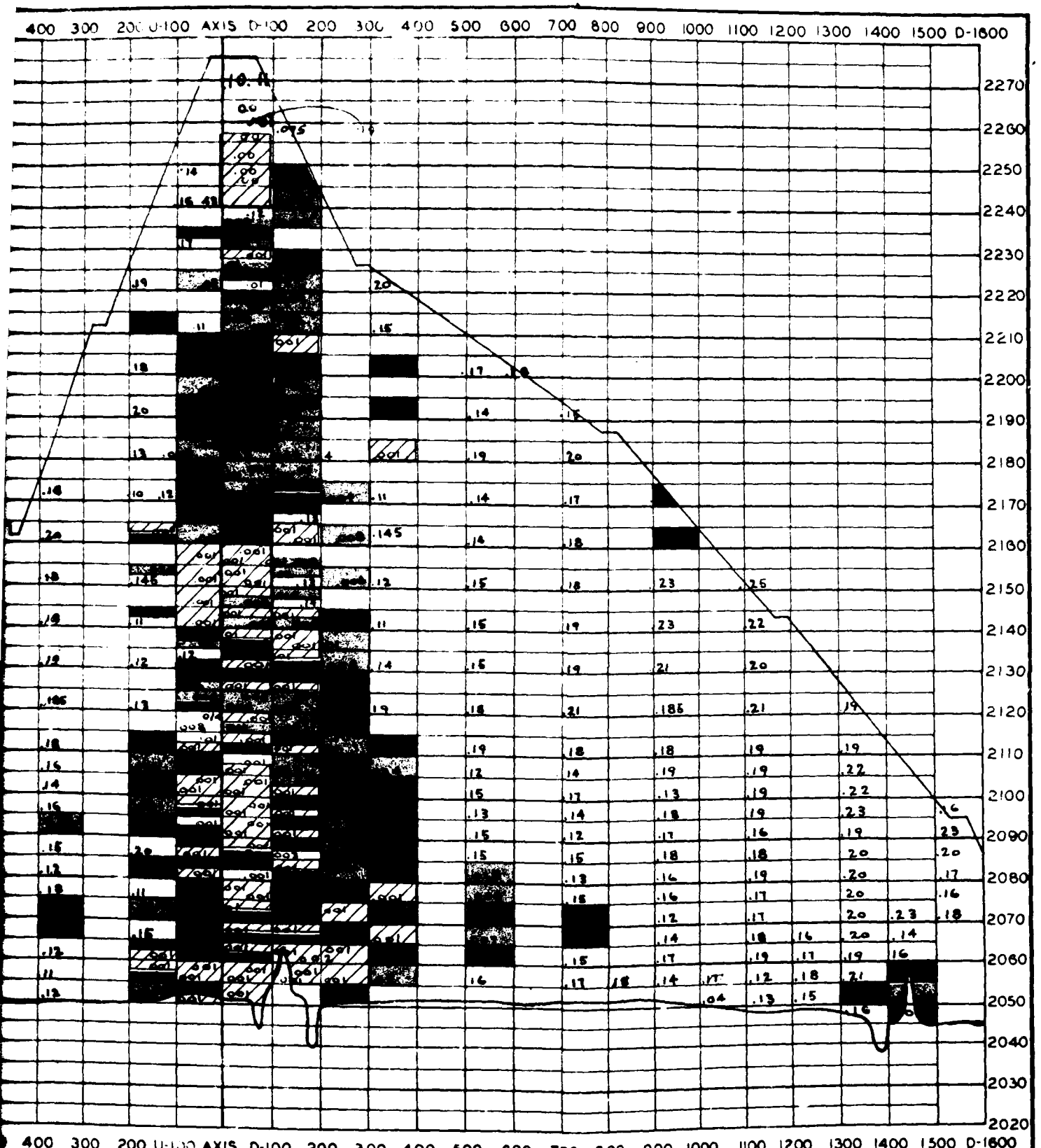


FORT PECK DAM AND RESERVOIR — EMBANKMENT CRITERIA AND PERFORMANCE REPORT — PLATE 4-2

2

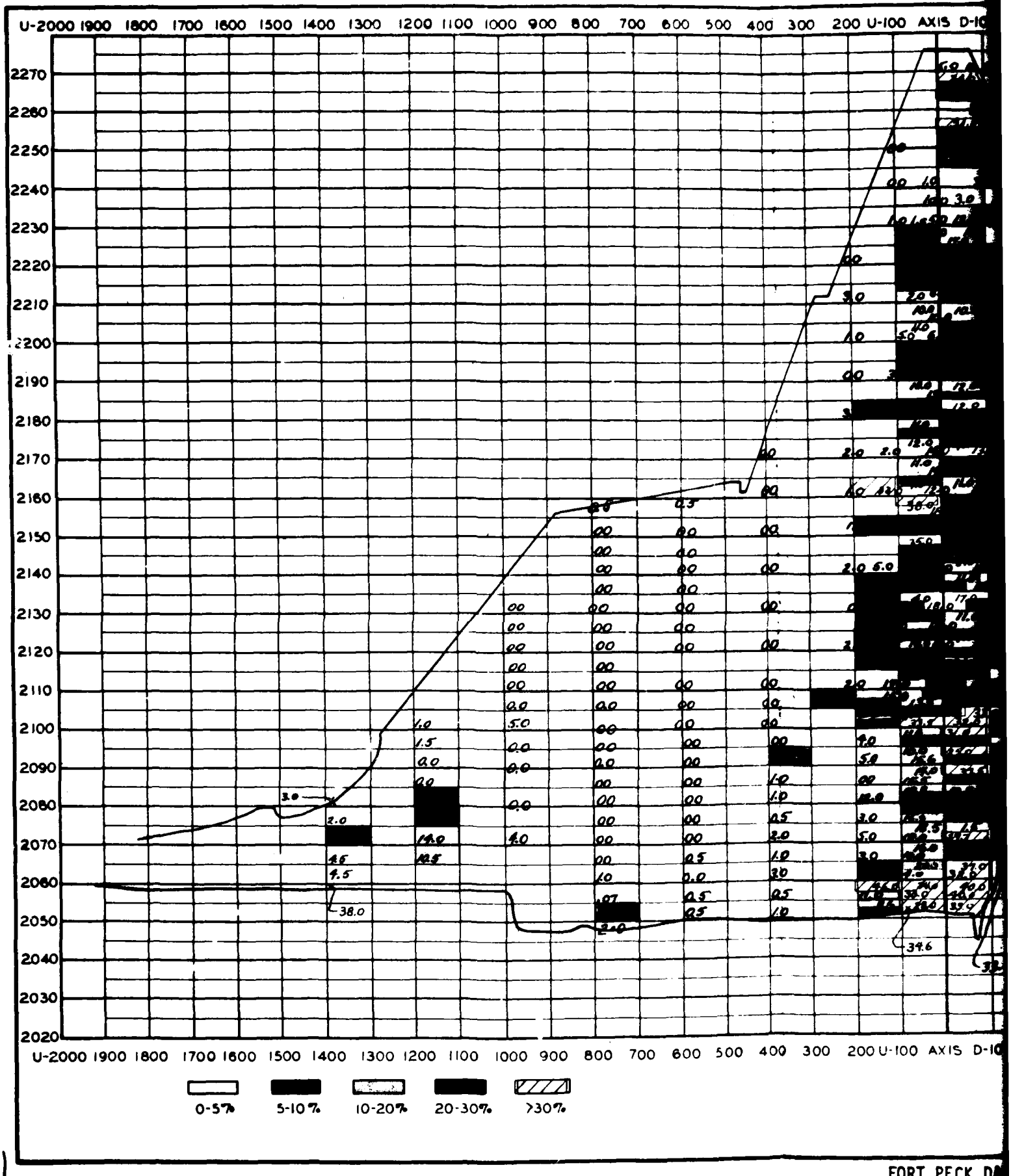

U-2000 1900 1800 1700 1600 1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 200 U-100 AXIS D-10
2270
2260
2250
2240
2230
2220
2210
2200
2190
2180
2170
2160
2150
2140
2130
2120
2110
2100
2090
2080
2070
2060
2050
2040
2030
2020
U-2000 1900 1800 1700 1600 1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 200 U-100 AXIS D-10
>.10
.10-.025
.025-.005
.005-.001
≤.001

FORT PECK DA

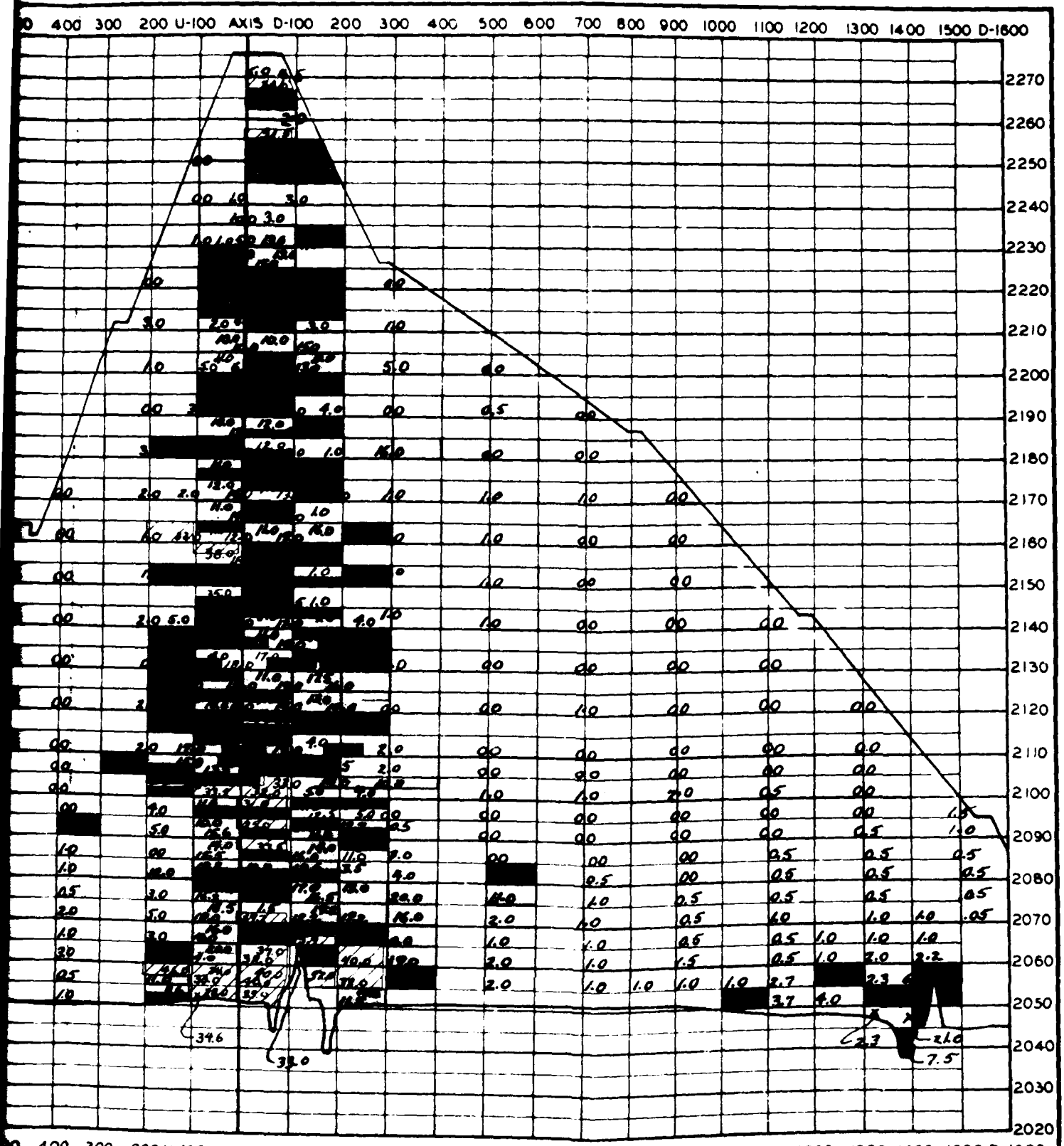


FORT PECK DAM

EFFECTIVE SIZE OF FILL SAMPLES, STA. 40+00
GROSS SECTION

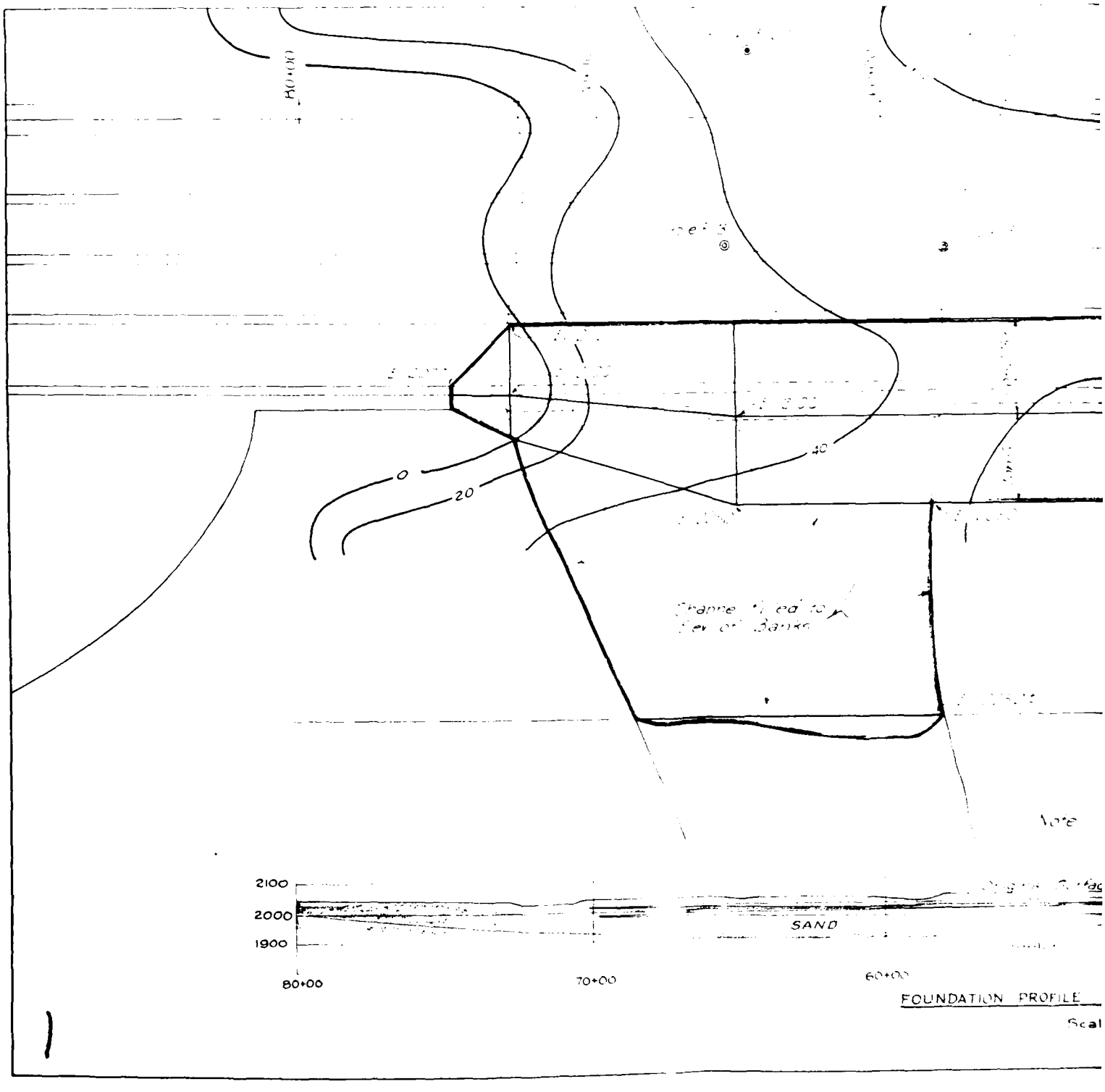

U-2000 1900 1800 1700 1600 1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 200 U-100 AXIS D-10
2270
2260
2250
2240
2230
2220
2210
2200
2190
2180
2170
2160
2150
2140
2130
2120
2110
2100
2090
2080
2070
2060
2050
2040
2030
2020
3.0
2.0
4.5
38.0
34.6
0-5%
5-10%
10-20%
20-30%
>30%

FORT PECK DA

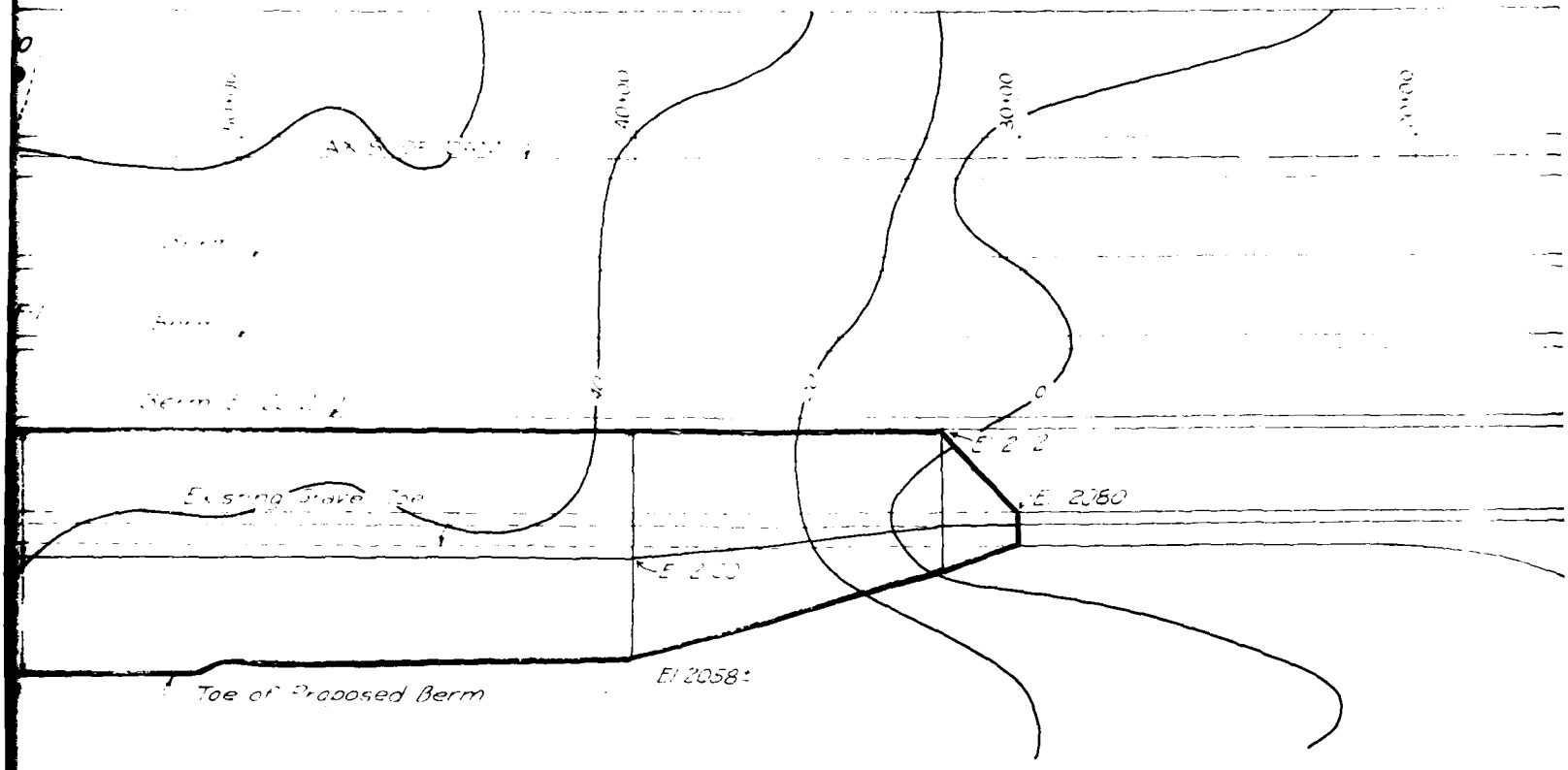


FORT PECK DAM

CLAY CONTENT OF FILL SAMPLES, STA. 40+00
GROSS SECTION



FOUNDATION PROFILE



Edge of Borrow Pit

PLAN

Scale 1" = 300

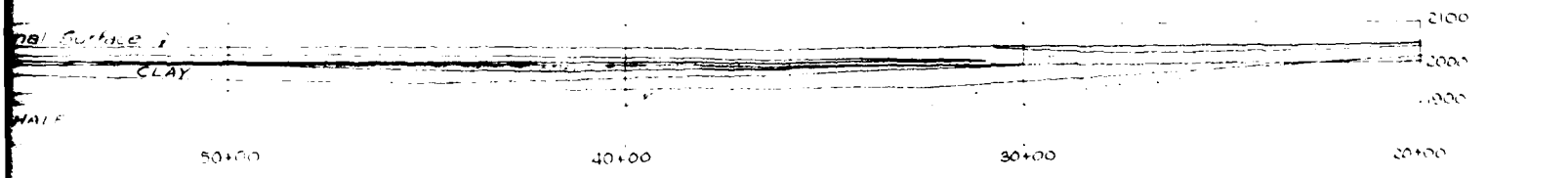
Note. Contours indicate approximate total thickness of clay strata in foundation

FORT PECK DA

STABILITY ANALYSIS- UPSTRE

PLAN OF PROPOSED

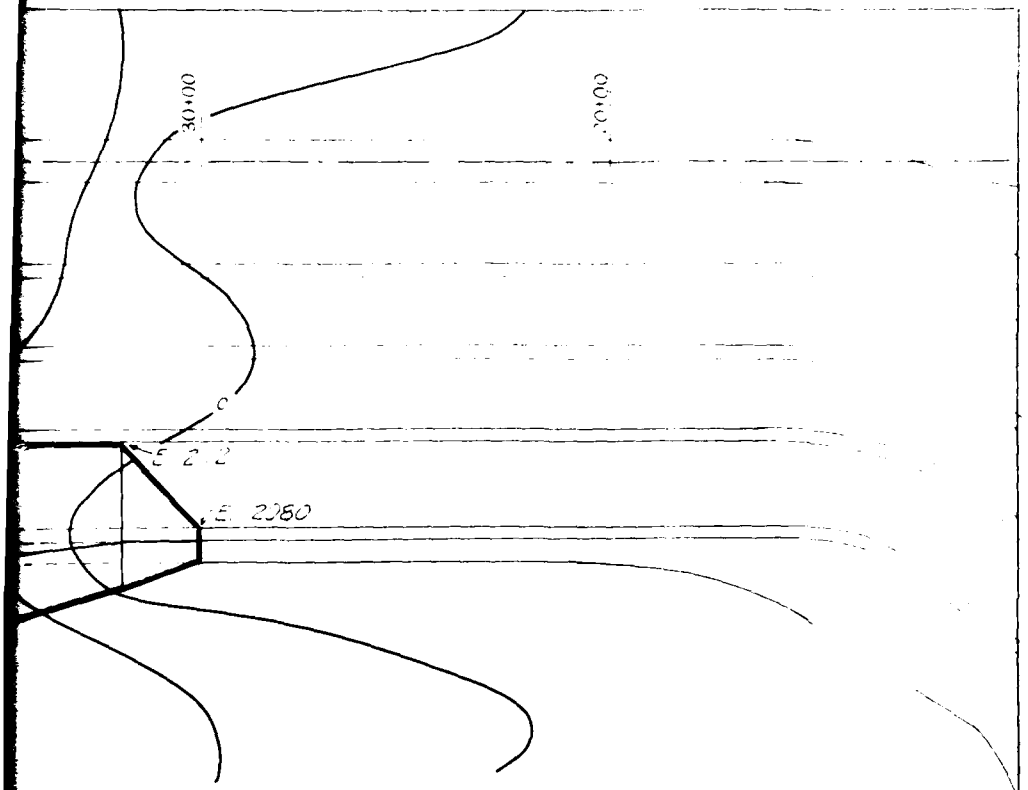
Prepared in Office of Divisio
Missouri River Divis



PROFILE 940' UPSTREAM FROM AXIS

Scale 1" = 300'

J

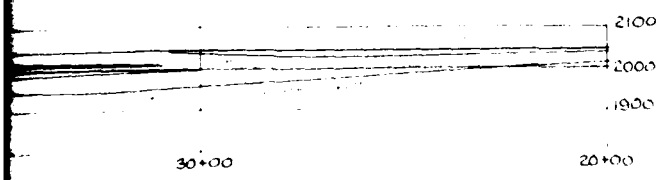


FORT PECK DAM

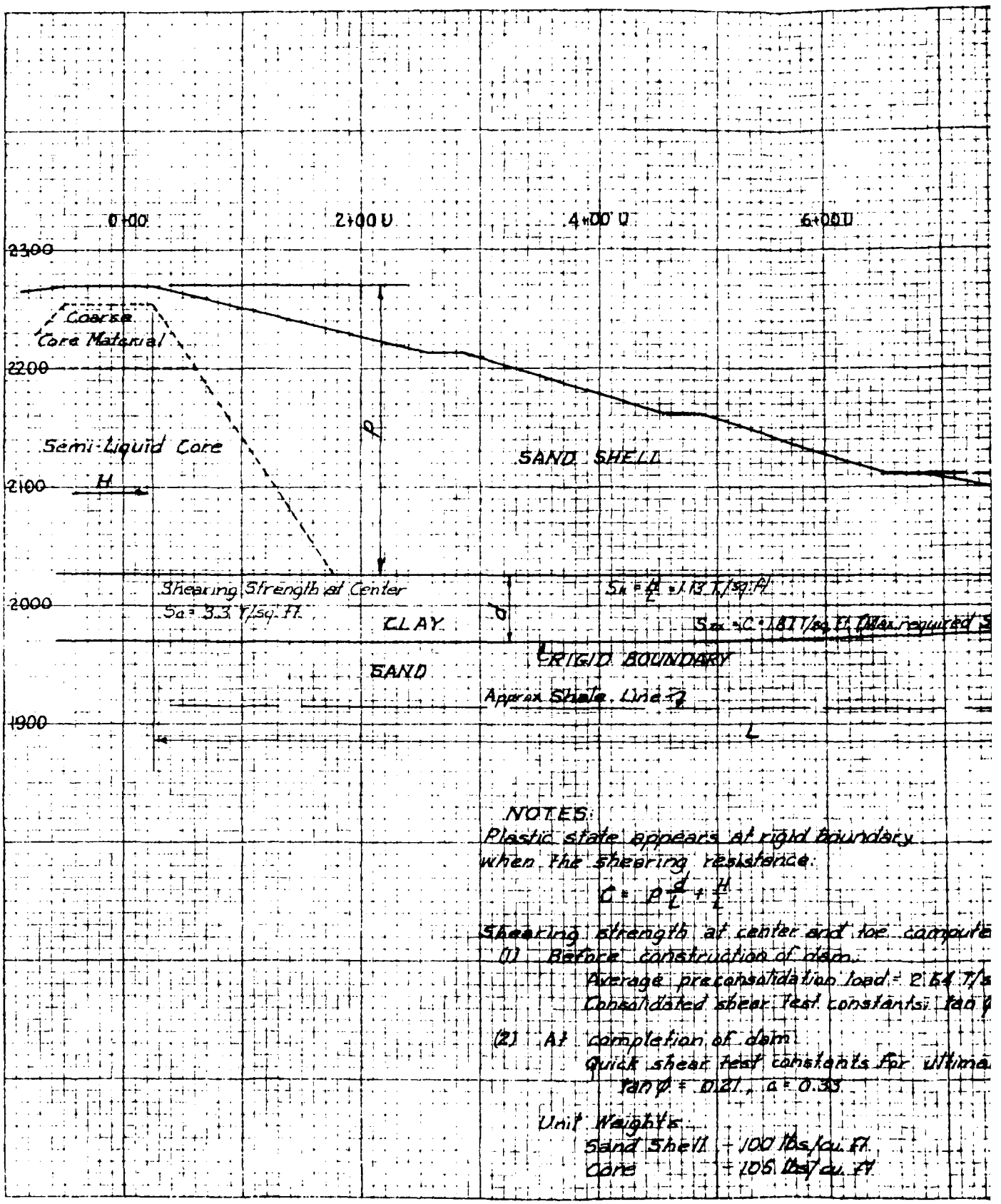
STABILITY ANALYSIS- UPSTREAM FOUNDATION

PLAN OF PROPOSED BERM

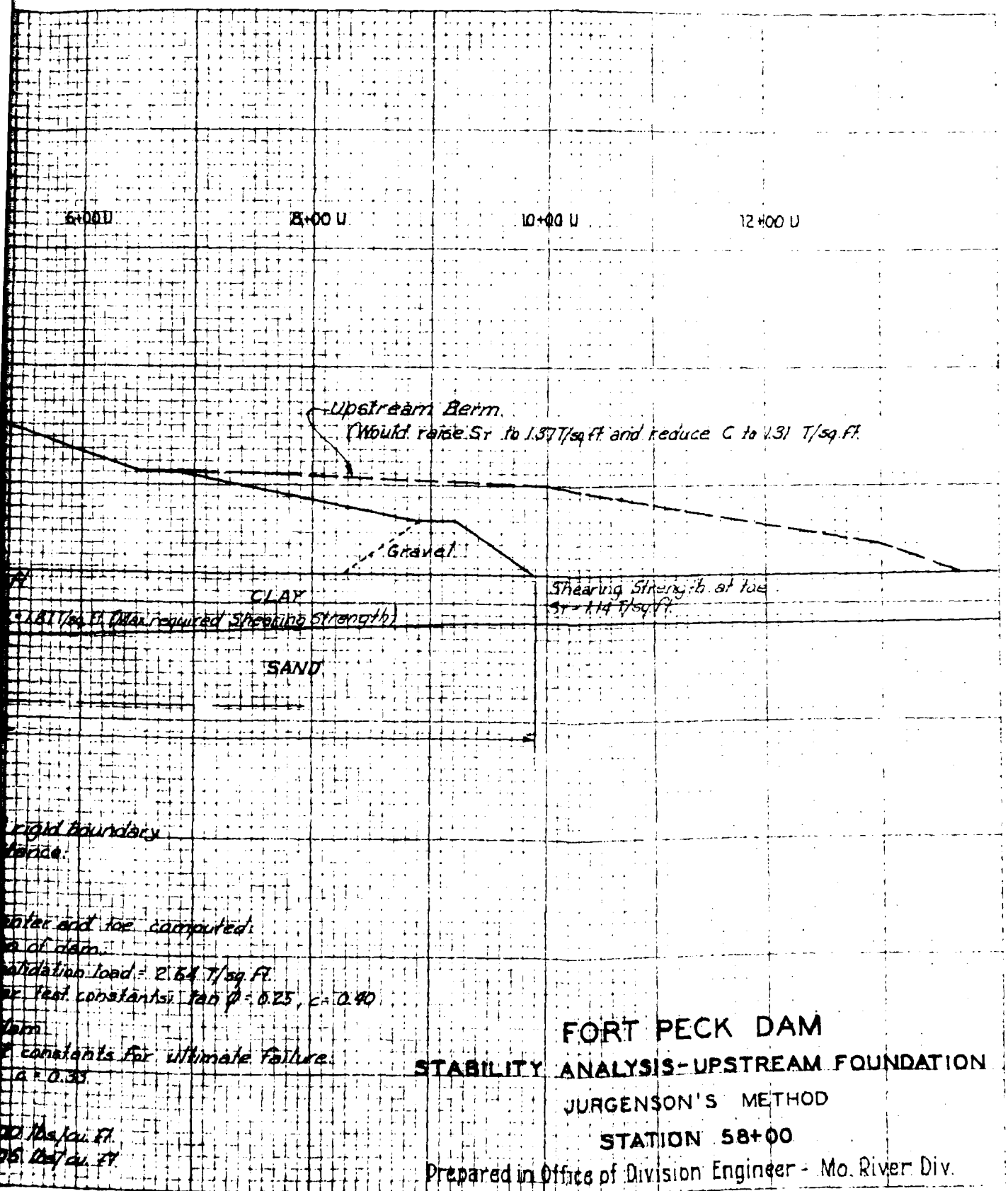
Prepared in Office of Division Engineer
Missouri River Division



3


0+00
2+00 U
4+00 U
6+00 U
2300
2200
2100
2000
1900
Coarse Core Material
Semi-Liquid Core
H
SAND SHELL
Shearing Strength at Center
Sa = 3.3 T/sq. ft.
CLAY
SAND
Sa = C + 181 T/sq. ft. (Max required S
RIGID BOUNDARY
Approx Shale Line
L
NOTES:
Plastic state appears at rigid boundary
when the shearing resistance
Shearing strength at center and toe compute
(1) Before construction of dam.
Average preconsolidation load = 2.64 T/s
Consolidated shear test constants: tan
(2) At completion of dam
Quick shear test constants for Ultima
Unit Weights
Sand Shell = 100 lbs/cu. ft.
Core = 106 lbs/cu. ft.

FORT PE



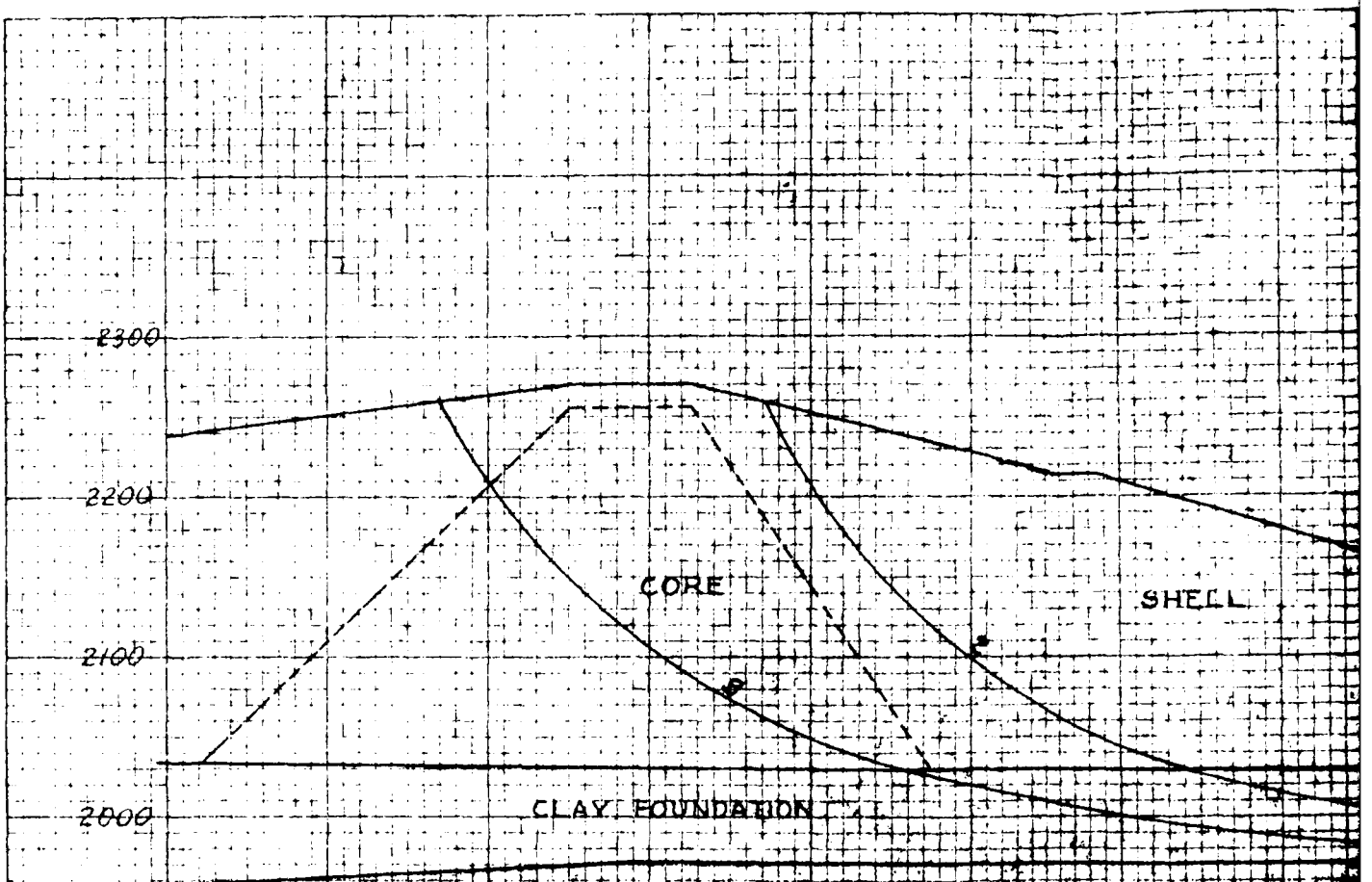
FORT PECK DAM

STABILITY ANALYSIS - UPSTREAM FOUNDATION

JURGENSON'S METHOD

STATION 58+00

Prepared in Office of Division Engineer - Mo. River Div.



CONSTANTS ADOPTED FOR ANALYSIS

SHELL Unit Wt. 100 lb/cu.ft. $\tan\phi = 0.65$ $c = 0$
(Saturated to elev. 2040)

CORE Unit Wt. 105 lb/cu.ft. $\tan\phi = 0.20$ $c = 0$
(Saturated to elev. 2200)

CLAY FOUNDATION Unit Wt. 120 lb/cu.ft.
(See Note for values of $\tan\phi$ and c

Case I

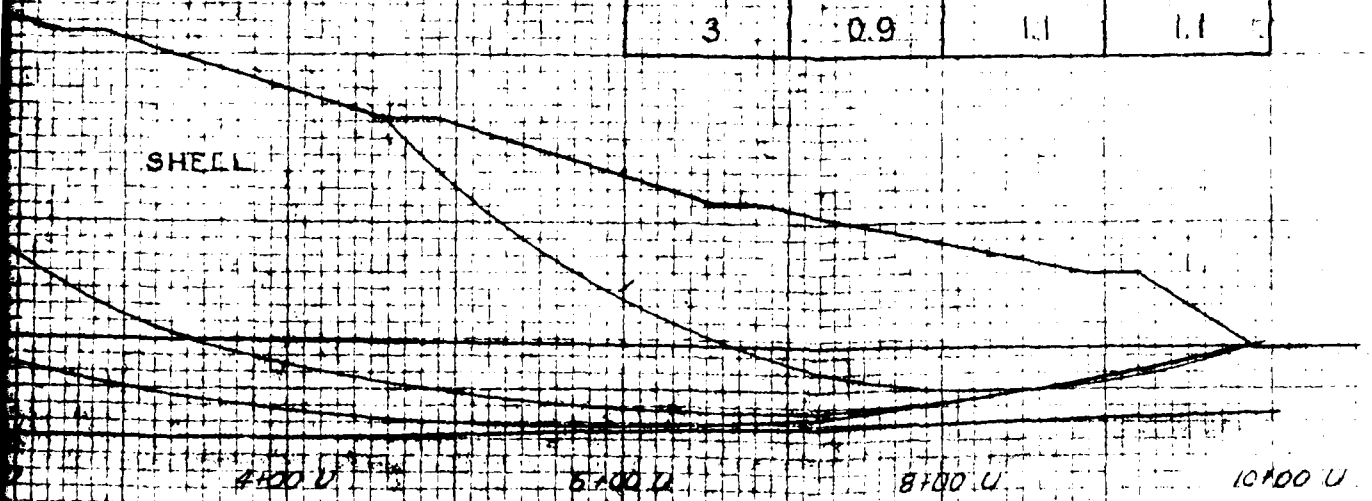
Case II

Case III

Samples for

FORT PEC

CURVE No.	FACTOR OF SAFETY		
	Case I	Case II	Case III
1	1.7	1.9	1.8
2	1.5	1.7	1.7
3	0.9	1.1	1.1



NOTE

Case I — $\tan\phi = 0.18$, $c = 0.5$ T/sq ft. — Constants determined by average of quick shear tests using load applied to sample at time of apparent yield point.

Case II — $\tan\phi = 0.21$, $c = 0.33$ T/sq ft. — Constants determined by average of quick shear tests using load applied to sample at time of ultimate failure.

Case III — $\tan\phi = 0.24$, $c = 0.12$ T/sq ft. — Constants determined by weighted average according to thickness of soil strata, using yield point test data for sampled strata and estimating $\tan\phi$ and c for non-sampled strata.

Samples for testing were obtained from holes F-1, F-3, F-10 and F-20.

FORT PECK DAM

STABILITY ANALYSIS - UPSTREAM FOUNDATION

CRITICAL SLIDING PLANE

SWEDISH METHOD - CIRCLE ANALYSIS

STATION 58+00

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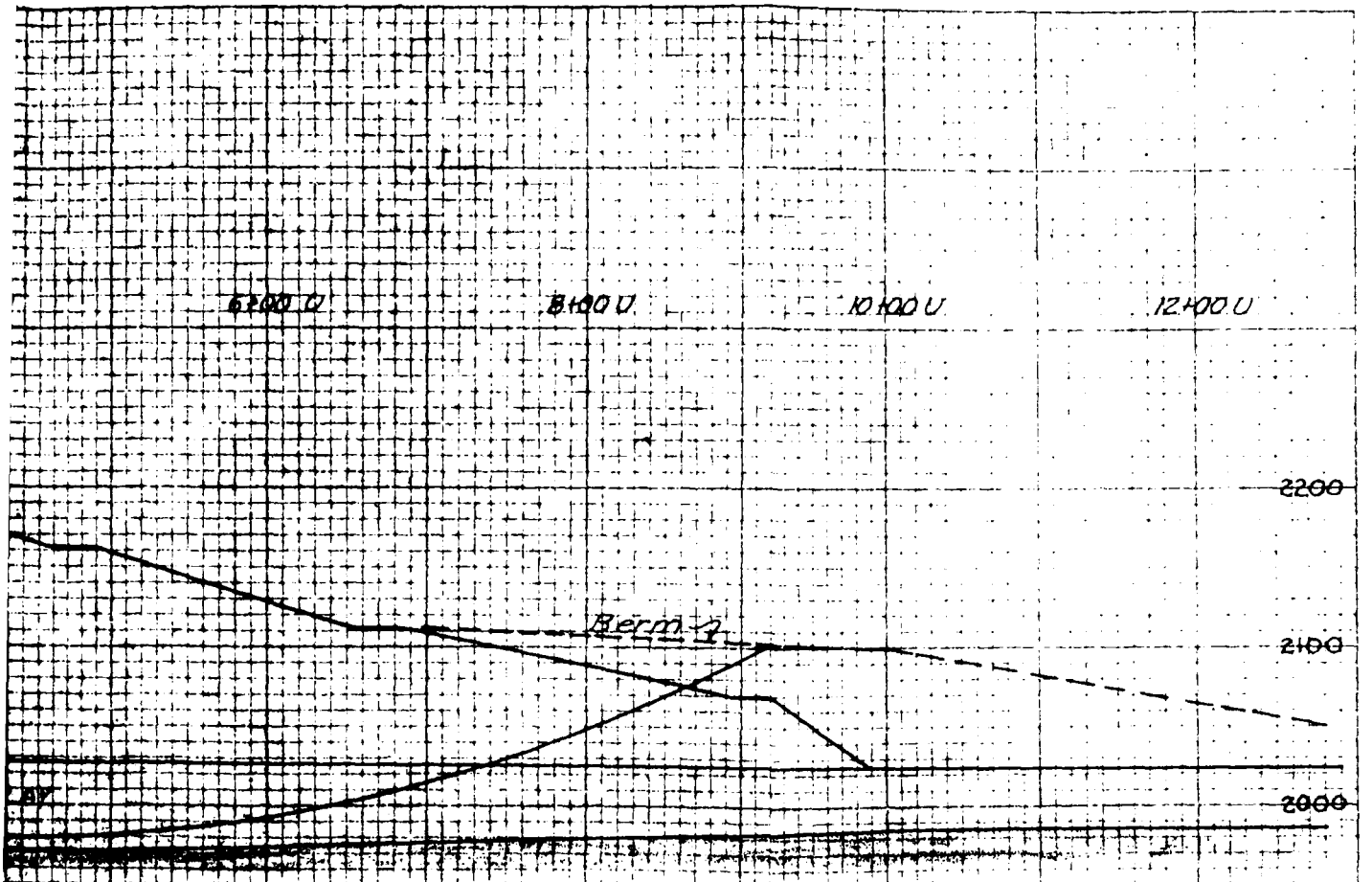
FORT PECK



FACTOR OF SAFETY		
Case I	Case II	Case III
1.2	1.4	1.4

See Fig. 2 For constants used in analysis.

FORT PECK DAM

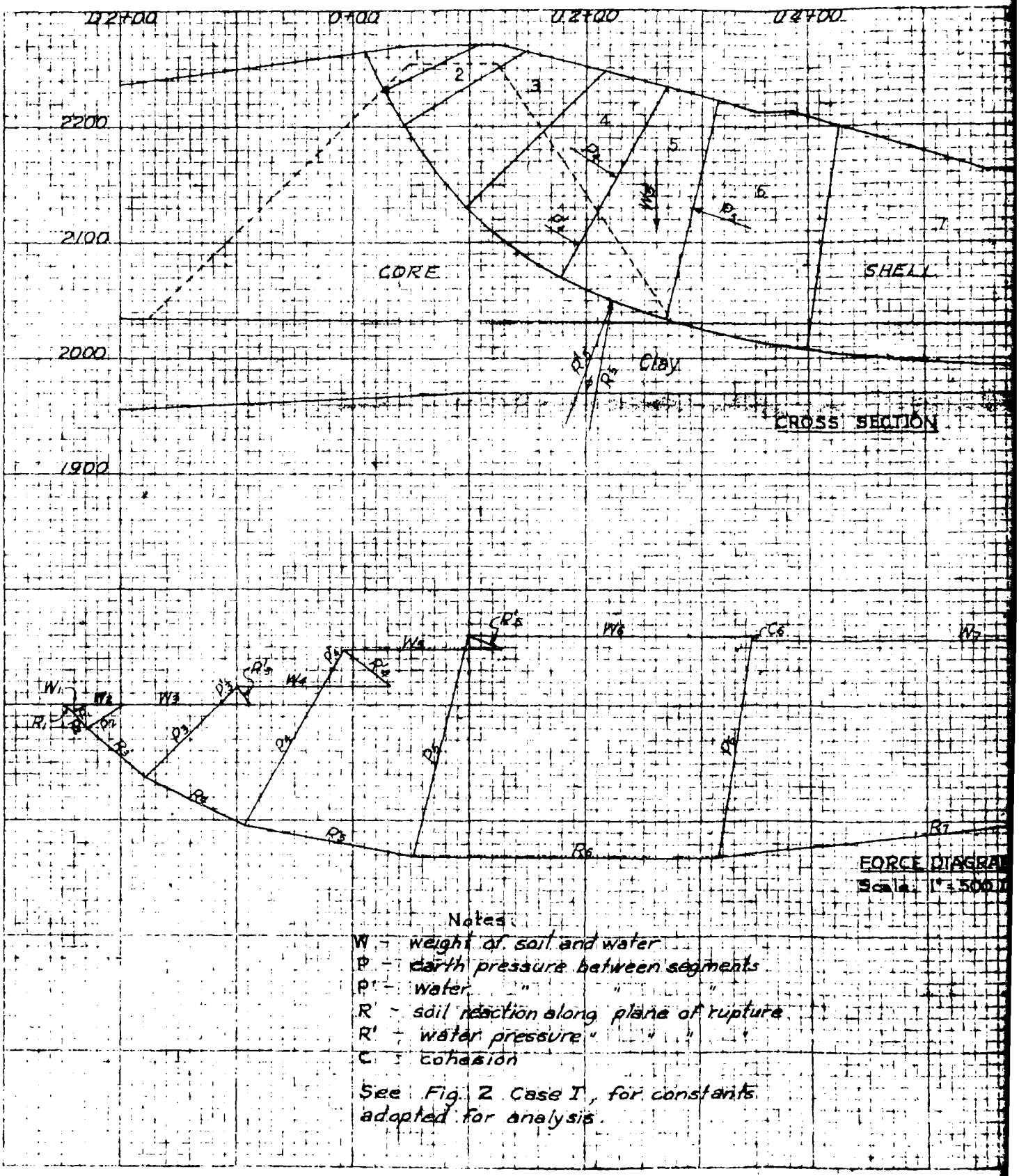
STABILITY ANALYSIS - UPSTREAM FOUNDATION

SWEDISH METHOD - CIRCLE ANALYSIS

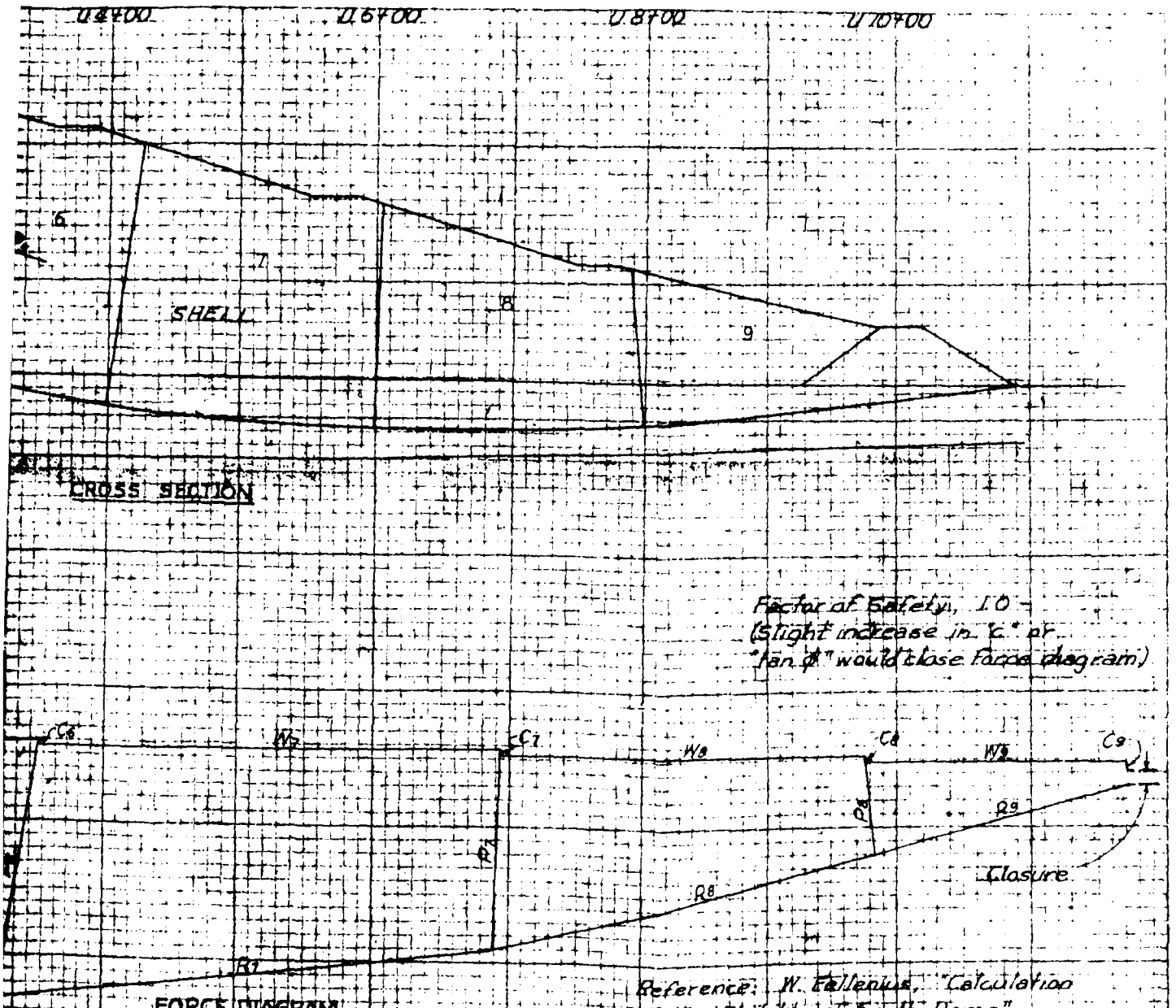
STA. 58+00 - WITH UPSTREAM BERM

Prepared in Office of Division Engineer: Mo. River Div.

2


2200
2100
2000
1900
CORE
SHELL
CLAY
CROSS SECTION
FORCE DIAGRAM
Scale 1" = 500'
Notes
W = weight of soil and water
P = earth pressure between segments
P' = water " " "
R' = soil reaction along plane of rupture
R' = water pressure " " " "
C = cohesion
See Fig. 2 Case I, for constants adopted for analysis.

FORT PECK



Reference: W. Fellenius, "Calculation of the Stability of Earth Dams." Second Congress on Large Dams - 1936

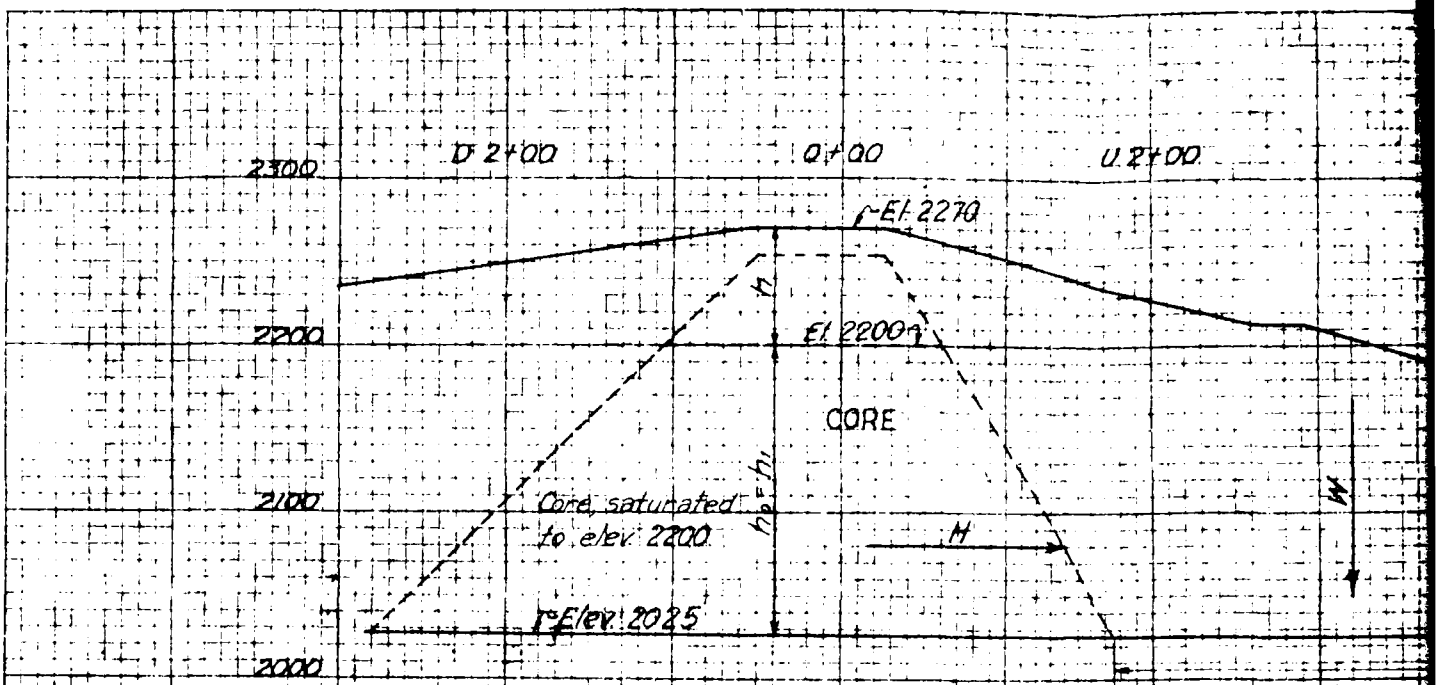
FORT PECK DAM

STABILITY ANALYSIS - UPSTREAM FOUNDATION

GRAPHICAL ANALYSIS

STATION 58+00

Prepared in Office of Division Engineer - Mo. River Div.



(Soil skeleton in saturated core carries weight of non-saturated core and shell above elev 2200)

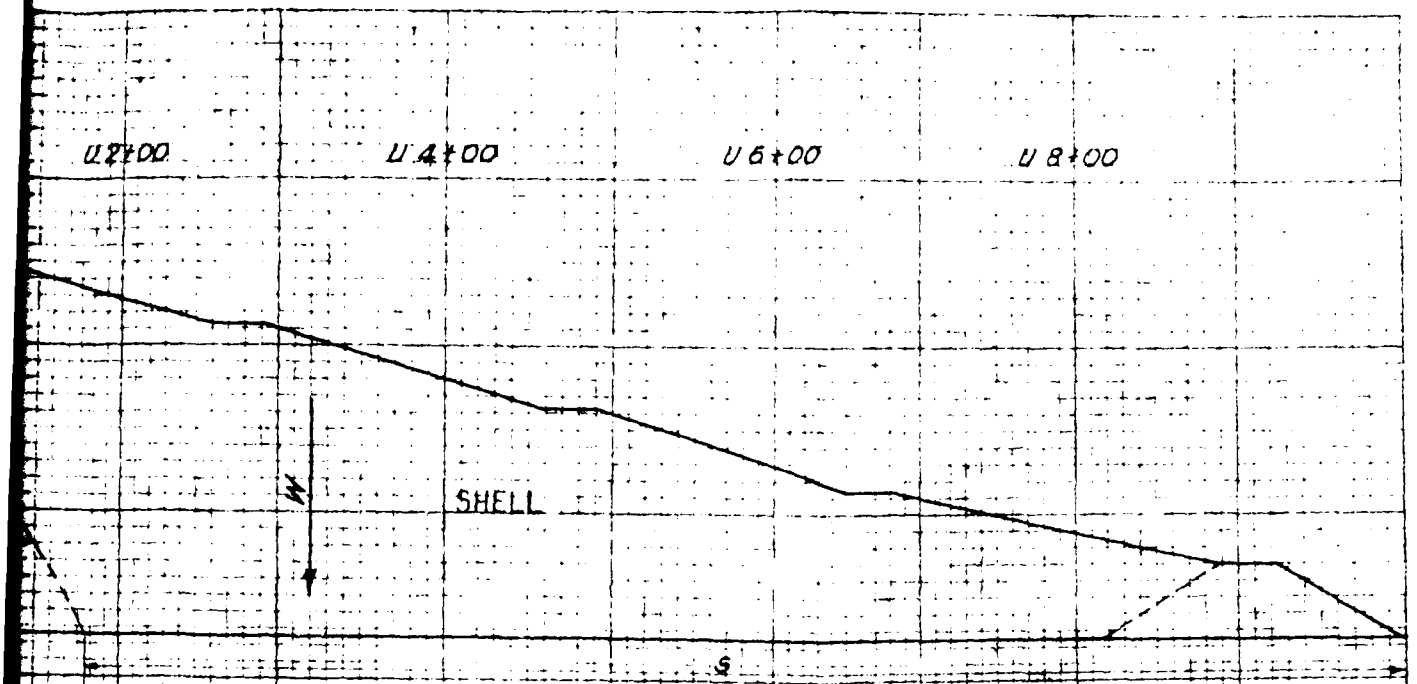
Horizontal Core Pressure, $H = \frac{w_o h_2^2}{2} + \frac{K h_1}{2}(2h_2 w + h_1 w_1) = 1125$ tons per linear ft of dam

$w_o = 62.5$ lb/cu ft, unit weight of water.
$h_2 = 17.5$ ft. head of water.
K = Ratio of horiz. to vertical pressure in soil skeleton, = 0.66
$w_1 = 42.5$ lb/cu ft., weight of soil skeleton in water.
$h_1 = 17.5$ ft. heighth of saturated core.
$h = 70$ ft. heighth of non-saturated core and shell.
$w = 105$ lb/cu ft. unit weight of non-saturated core.

Weight of Shell, $W = 5342$ tons per linear ft of dam.
(Unit weight of shell material = 100 lb/cu ft.)

S = Area of base of shell per linear ft of dam = 815 sq ft.
c = Cohesion of foundation = 0.15 T/sq ft (Case I*)
$\tan\phi$ = Coefficient of friction in foundation = 0.18 (Case I*)

* See Notes, Fig 2



linear ft of dam

ft

d in soil skeleton, = 0.66

ort in water

d

core and shell

saturated core.

uft)

dam = 815 sq ft

(Case I*)

0.18 (Case I*)

Factor of Safety against sliding along base =

$$\frac{W \tan \phi + cs}{H} = \frac{5342 \times .18 + 815 \times .15}{1125} = 0.96 \text{ Case I*}$$

$$= \frac{5342 \times .21 + 815 \times .33}{1125} = 1.24 \text{ Case II*}$$

$$= \frac{5342 \times .24 + 815 \times .12}{1125} = 1.23 \text{ Case III*}$$

FORT PECK DAM

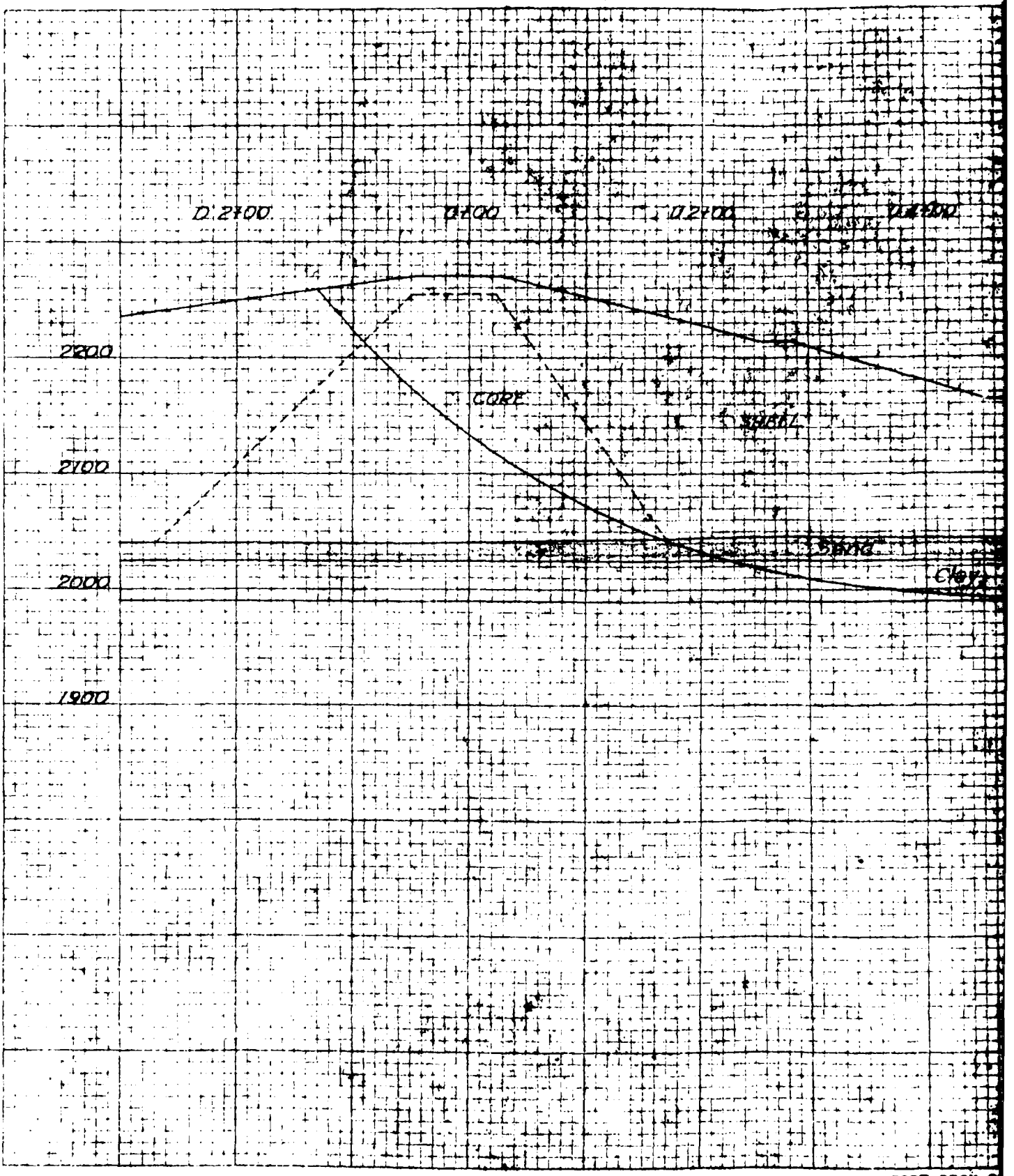
STABILITY ANALYSIS - UPSTREAM FOUNDATION

SLIDE ALONG CLAY FOUNDATION
DUE TO CORE PRESSURE

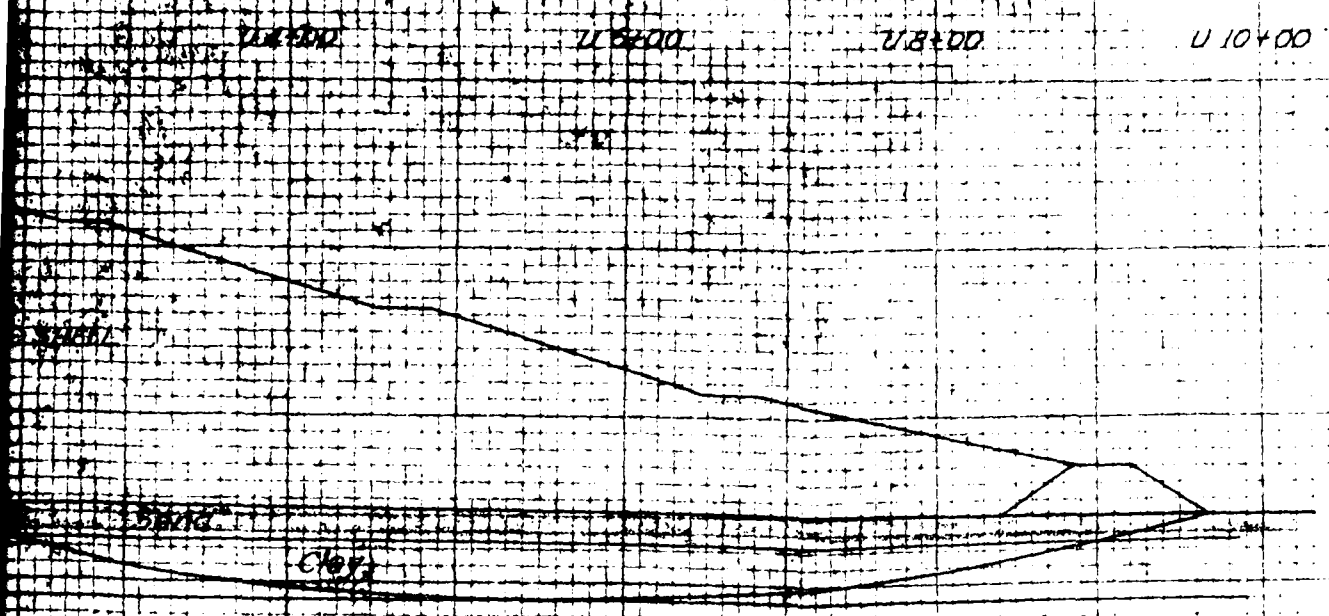
STATION 58+00

Prepared in Office of Division Engineer - Mo River Div.

2



FORT PECK



FACTOR OF SAFETY		
Case I	Case II	Case III
1.3	1.4	1.4

Sand Foundation. tan ϕ = 0.65 ; c = 0
See Fig. 2 for other constants used in analysis

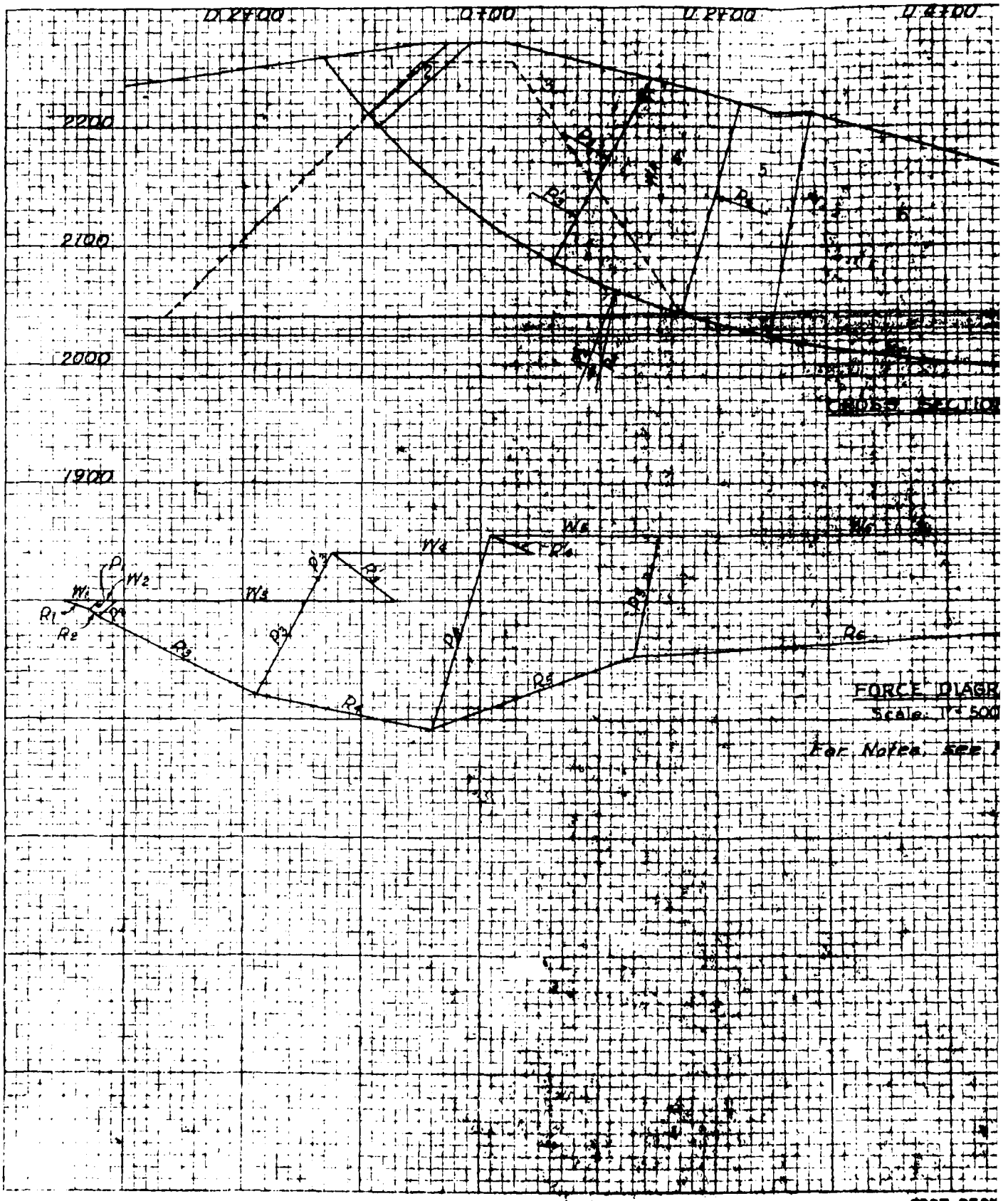
FORT PECK DAM

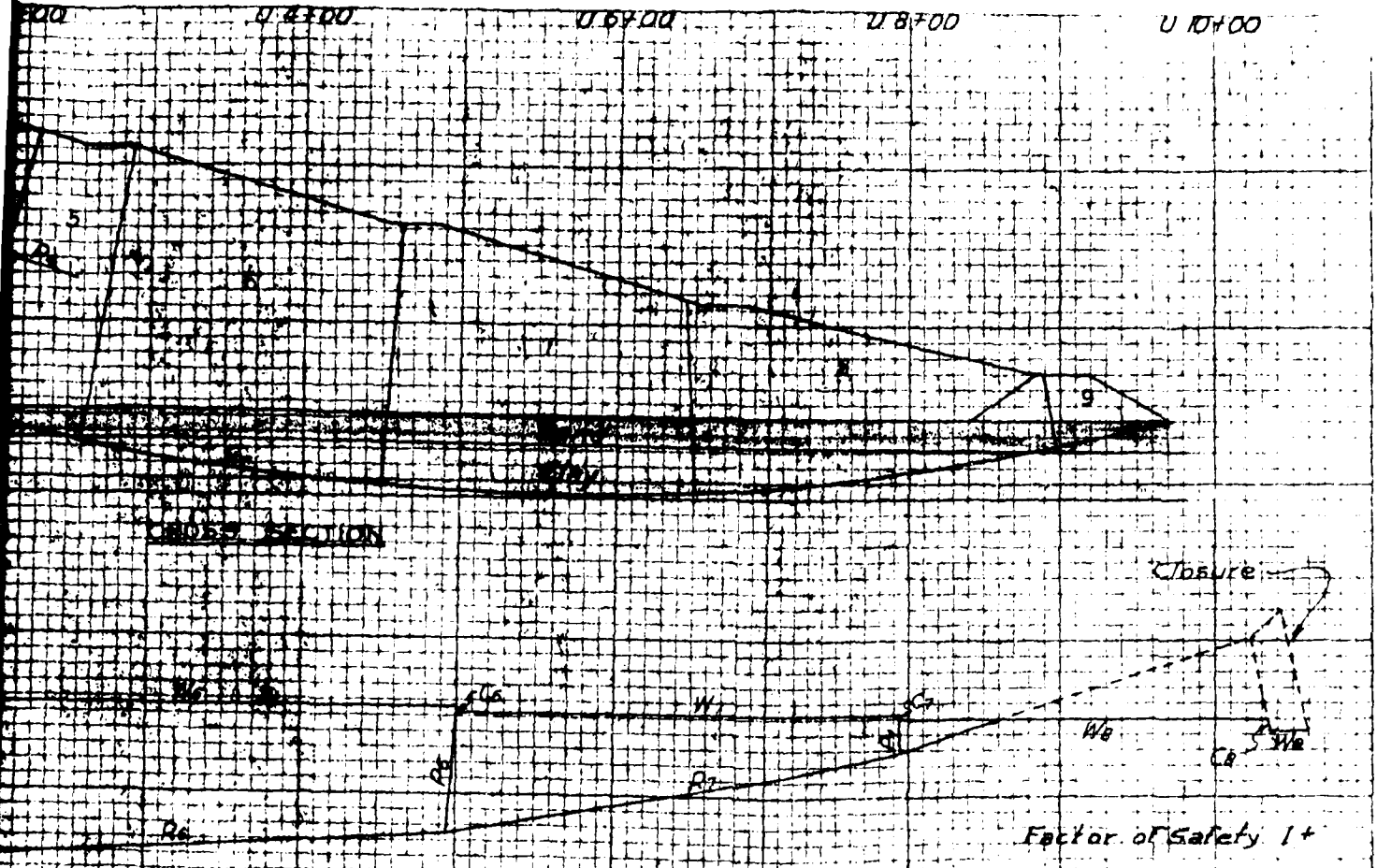
STABILITY ANALYSIS - UPSTREAM FOUNDATION

SWEDISH METHOD - CIRCLE ANALYSIS

STATION 65+00

Prepared in Office of Division Engineer - Mo. River Div.


D 2700
D 2700
D 2700
D 2700
22000
21000
20000
19000
CROSS SECTIO
W1
W2
W3
W4
W5
W6
R1
R2
R3
R4
R5
R6
FORCE DIAGR
Scale: 1" = 500
For Notes, see
FORT PECK



FORCE DIAGRAM
Scale: 1" = 500 Tons

For Notes, see Fig. 4

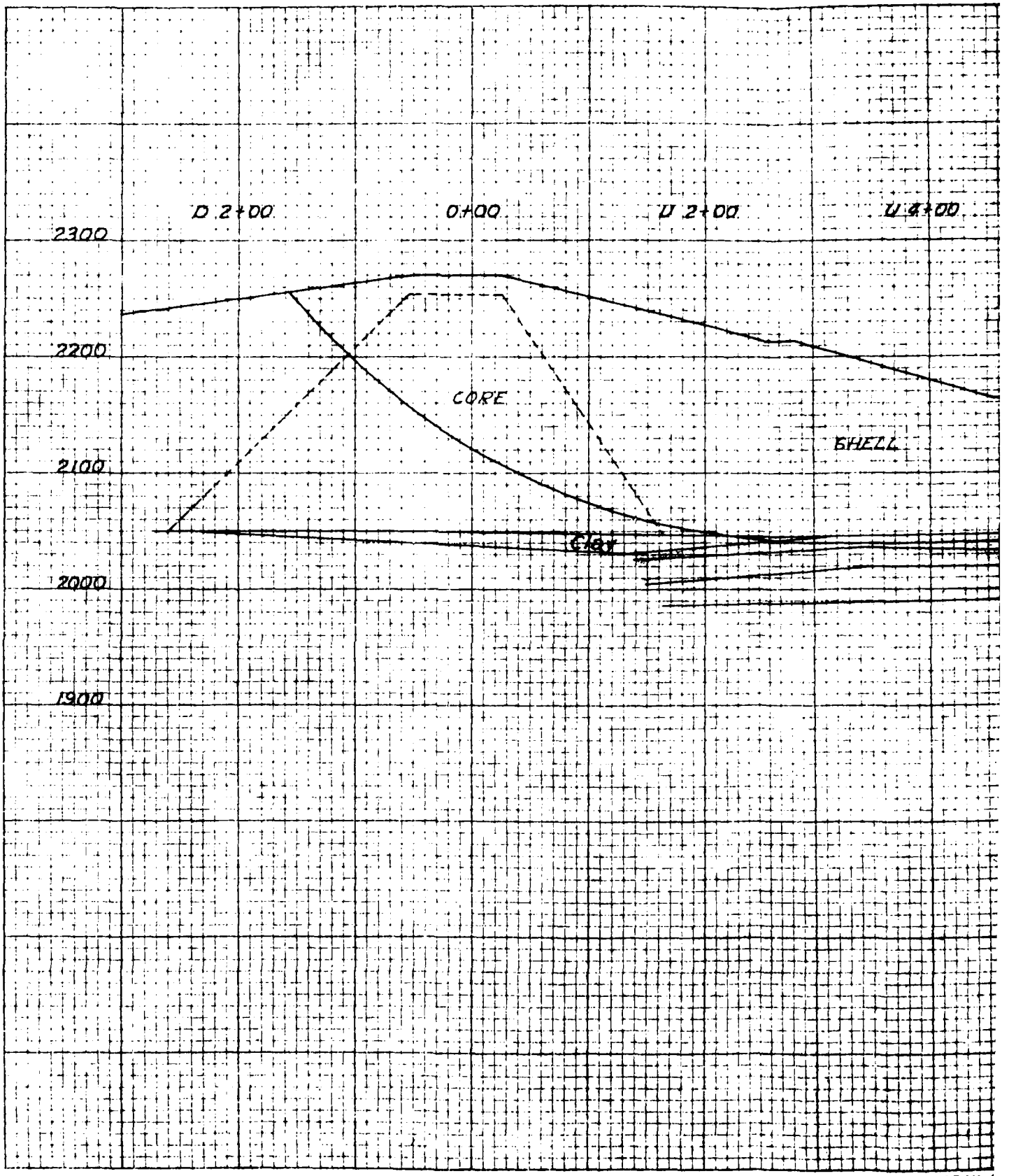
FORT PECK DAM

STABILITY ANALYSIS - UPSTREAM FOUNDATION

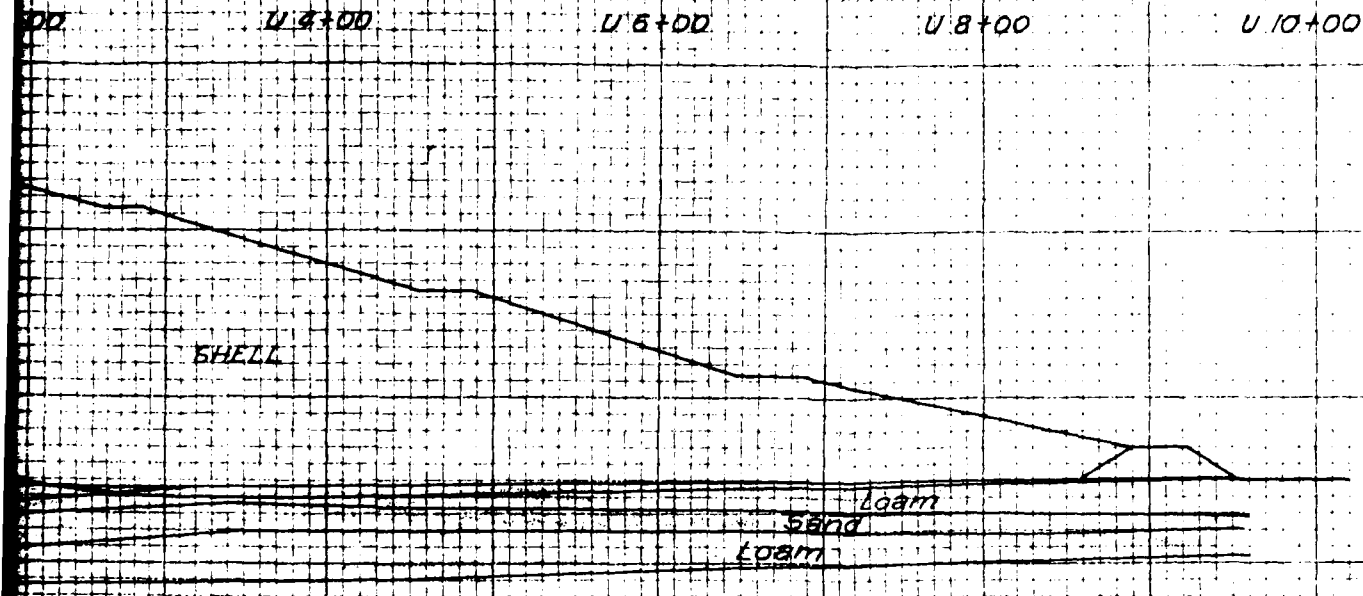
GRAPHICAL ANALYSIS

STATION 65+00

Prepared in Office of Division Engineer, Mo. River Div.



FORT PECK



FACTOR OF SAFETY = 1.9 (All Cases)

Loam Foundation ... $\tan\phi = .50$, $c = 0$
Sand " $\tan\phi = .65$, $c = 0$
For other constants used in analysis, see Fig. 2

FORT PECK DAM

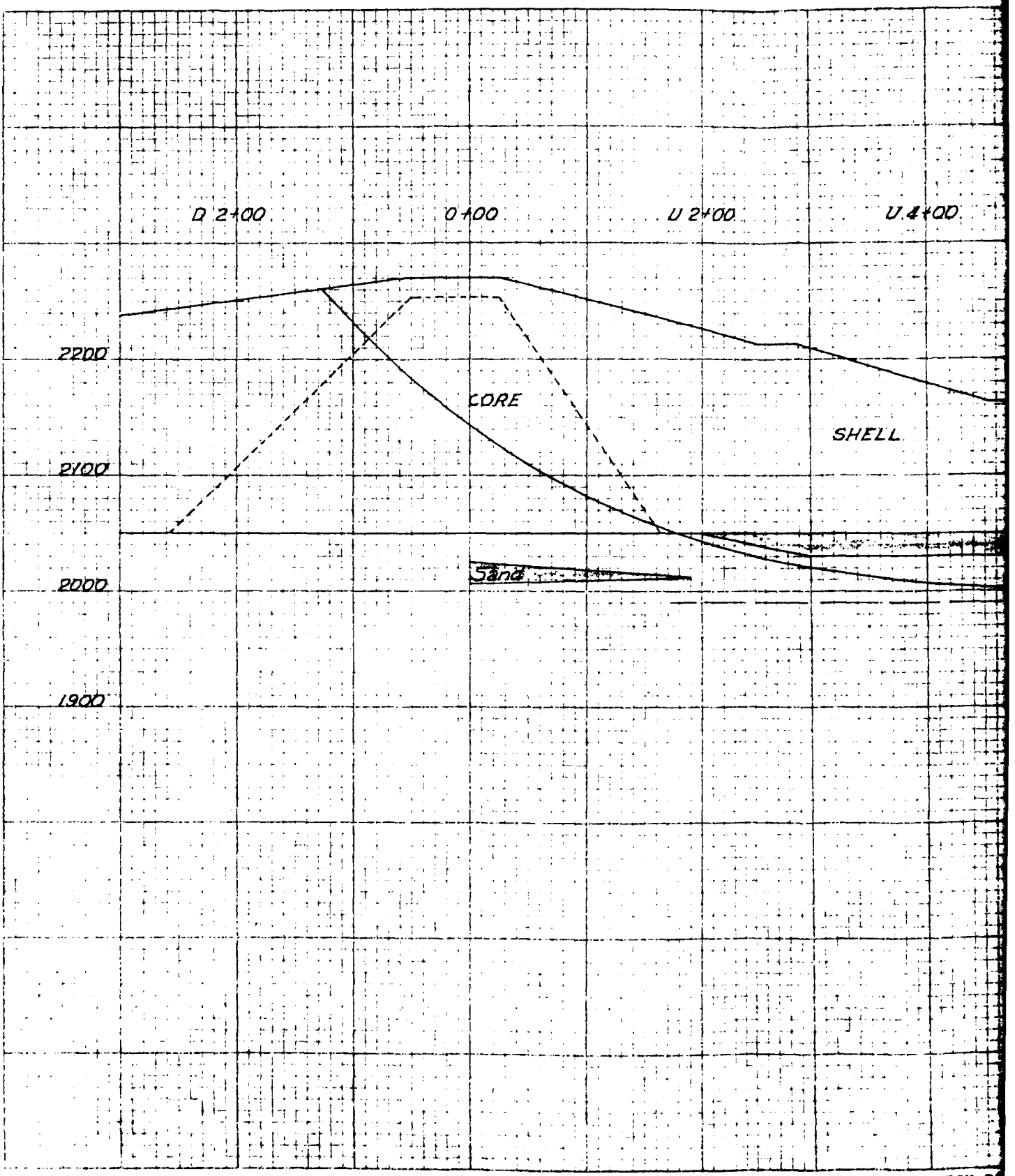
STABILITY ANALYSIS - UPSTREAM FOUNDATION

SWEDISH METHOD - CIRCLE ANALYSIS

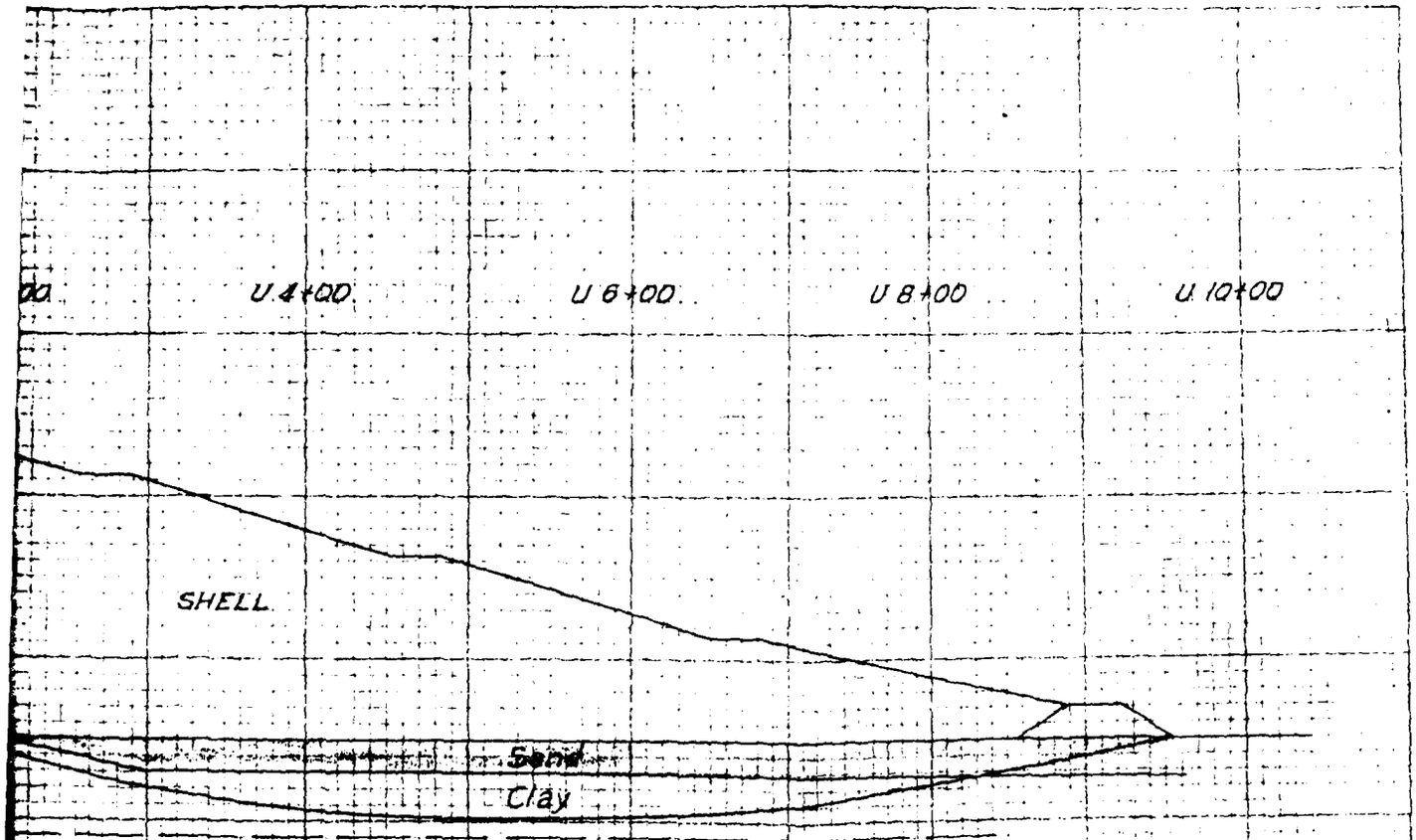
STATION 75+00

Prepared in Office of Division Engineer, Mo. River Div.

2



FORT PECK D



FACTOR OF SAFETY		
Case I	Case II	Case III
1.0	1.3	1.3

Sand foundation: $\tan\phi = 0.65$, $c = 0$.
See Fig. 2 for other constants used in analysis.

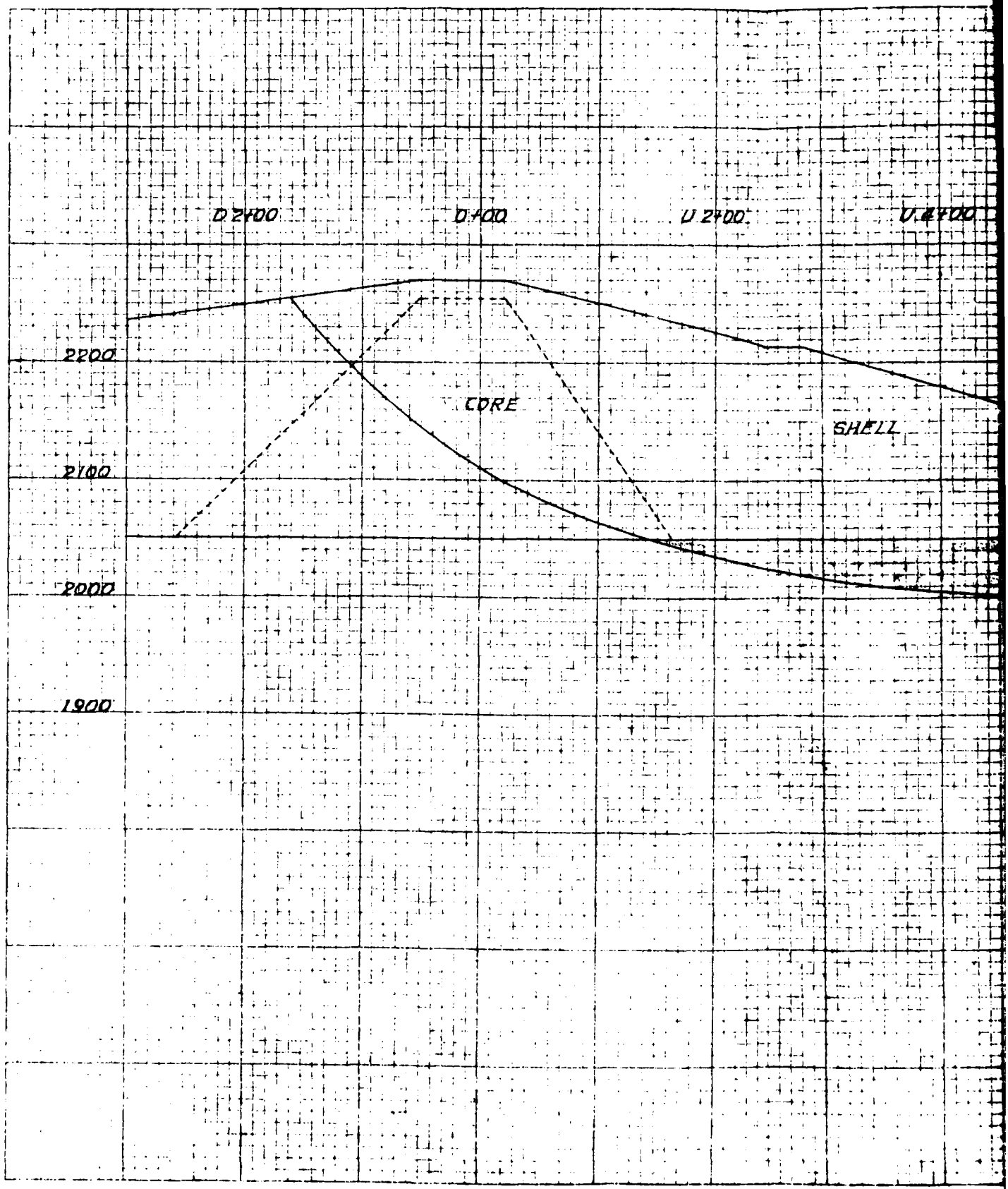
FORT PECK DAM

STABILITY ANALYSIS - UPSTREAM FOUNDATION

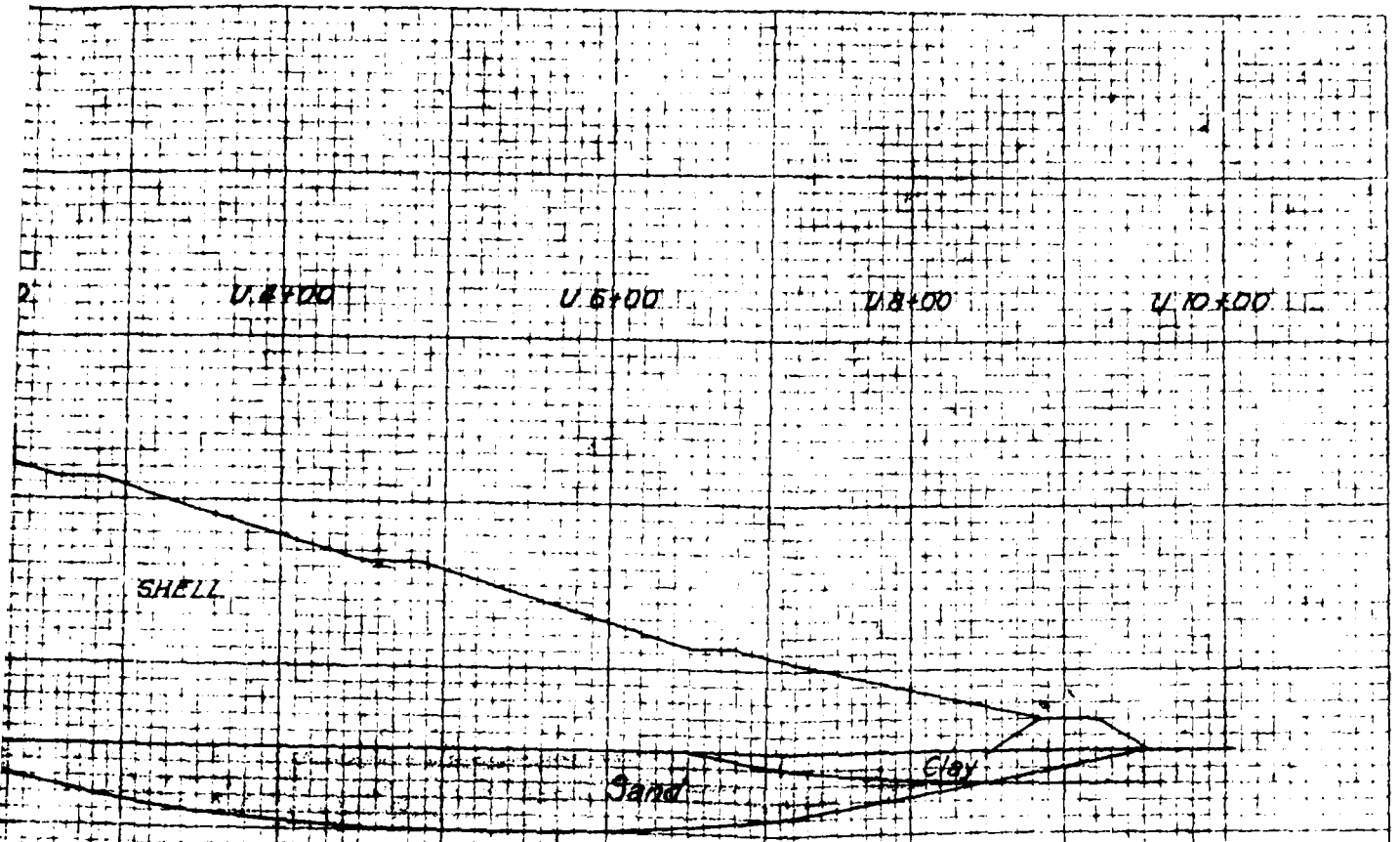
SWEDISH METHOD - CIRCLE ANALYSIS

STATION 40+00

Prepared in Office of Division Engineer - Mo. River Div.



FORT PECK



FACTOR OF SAFETY = 2.9 (All Cases)
Sand Foundation tan ϕ = 0.65, c = 0
See Fig. 2 for other constants used in analysis

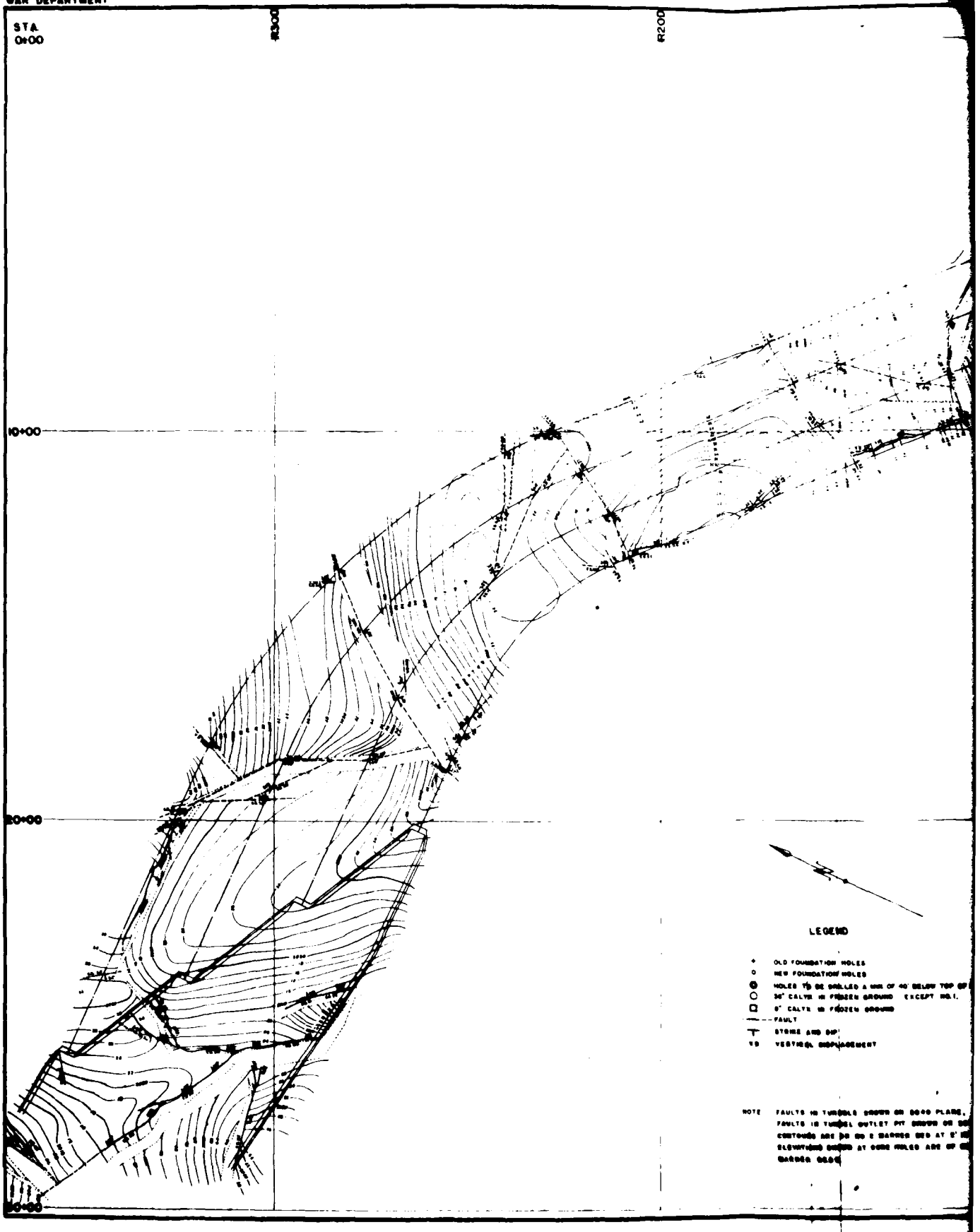
FORT PECK DAM

STABILITY ANALYSIS - UPSTREAM FOUNDATION

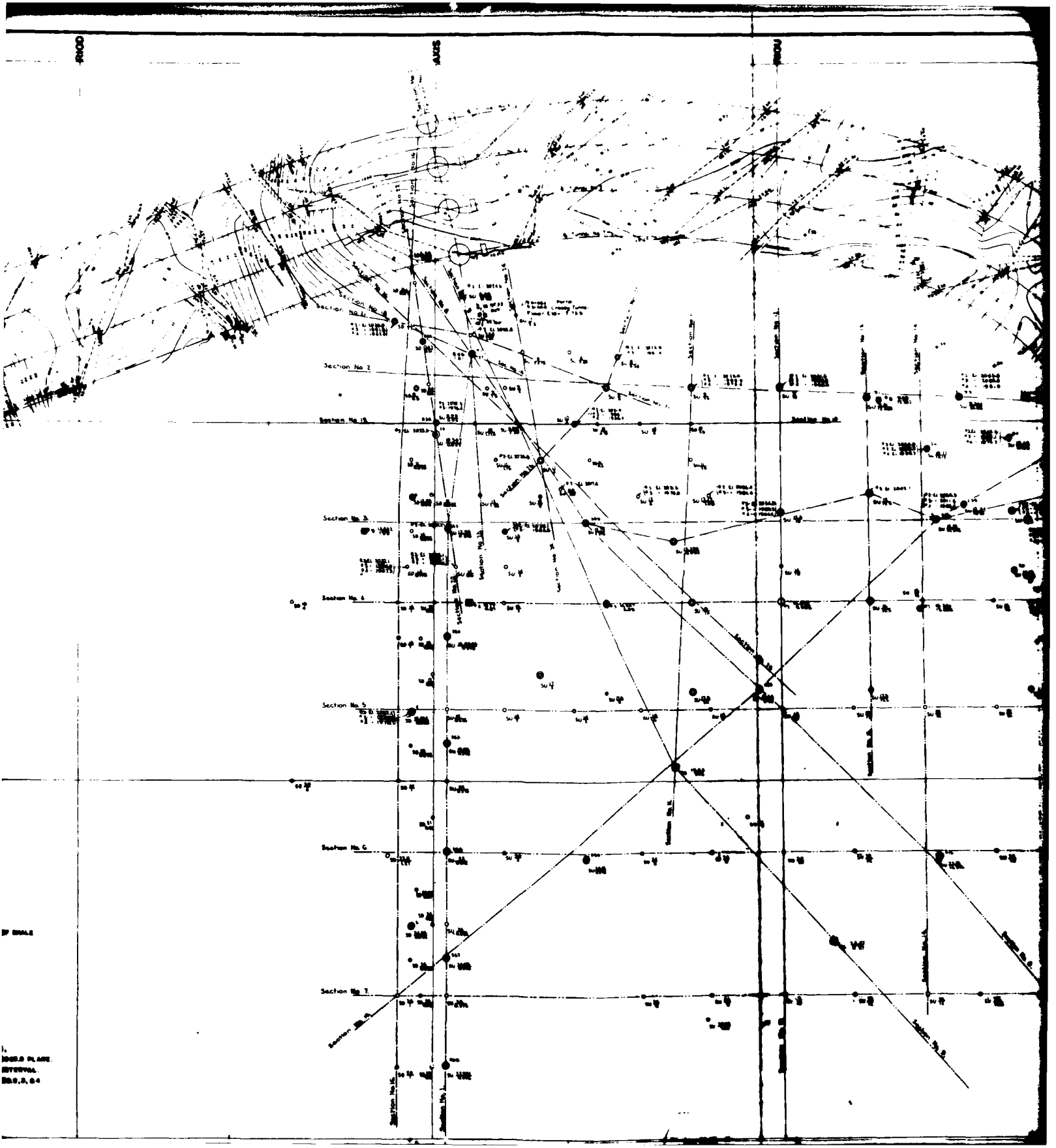
SWEDISH METHOD - CIRCLE ANALYSIS

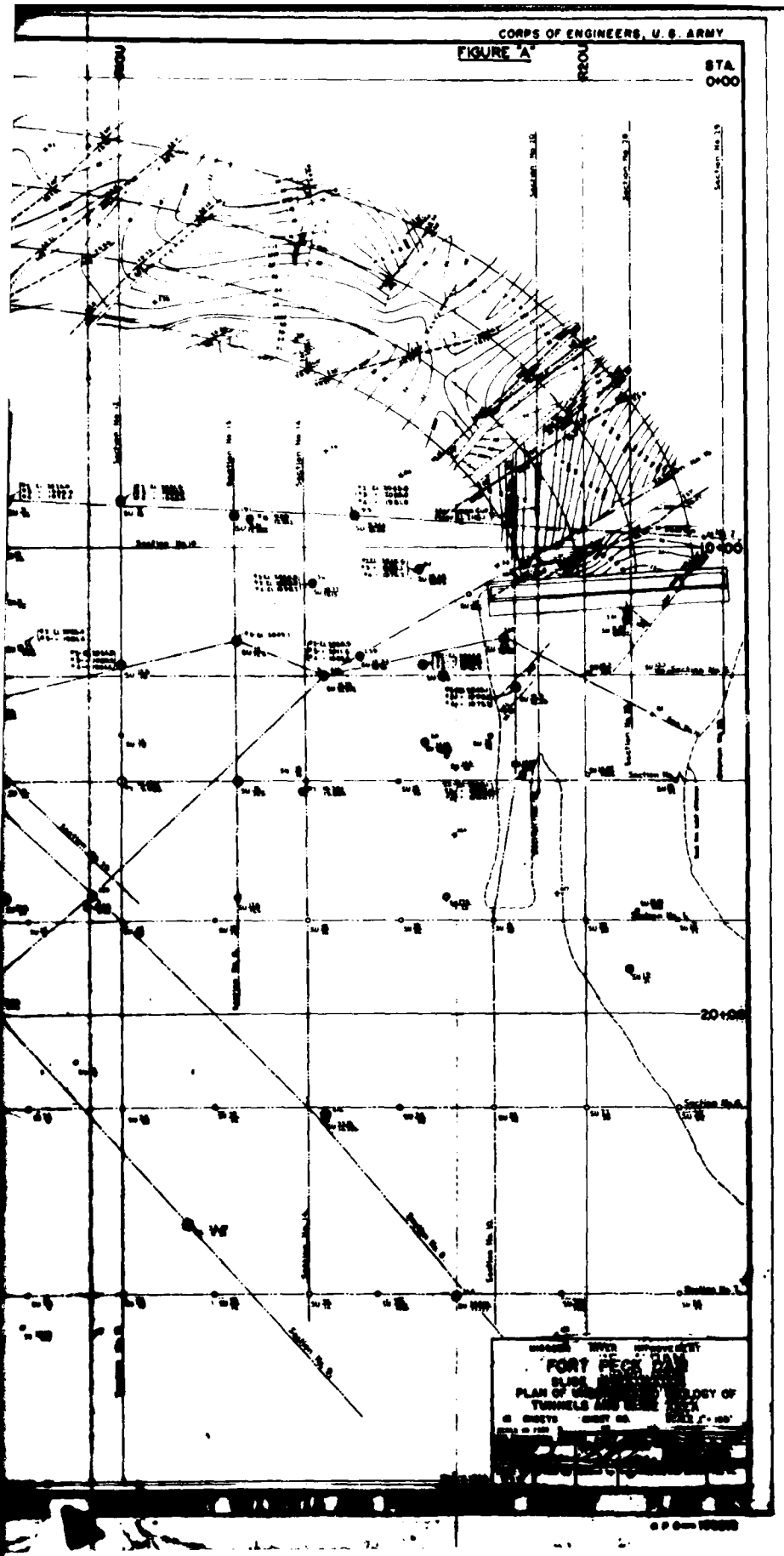
STATION 25+00

Prepared in Office of Division Engineer - Mo. River Div.


STA
0+00
R300
R200
10+00
20+00
30+00
LEGEND
OLD FOUNDATION HOLES
NEW FOUNDATION HOLES
HOLES TO BE DRILLED A MIN OF 40' BELOW TOP OF
36" CALYX IN FROZEN GROUND EXCEPT NO.1.
6" CALYX IN FROZEN GROUND
FAULT
STRIKE AND DIP
VERTICAL DISPLACEMENT
NOTE

(Page p. 23) No. 1


Section No 2
Section No 3
Section No 4
Section No 5
Section No 6
Section No 7


CORPS OF ENGINEERS, U.S. ARMY
FIGURE "A"
STA.
0+00
10+00
20+00
FORT PECK DAM

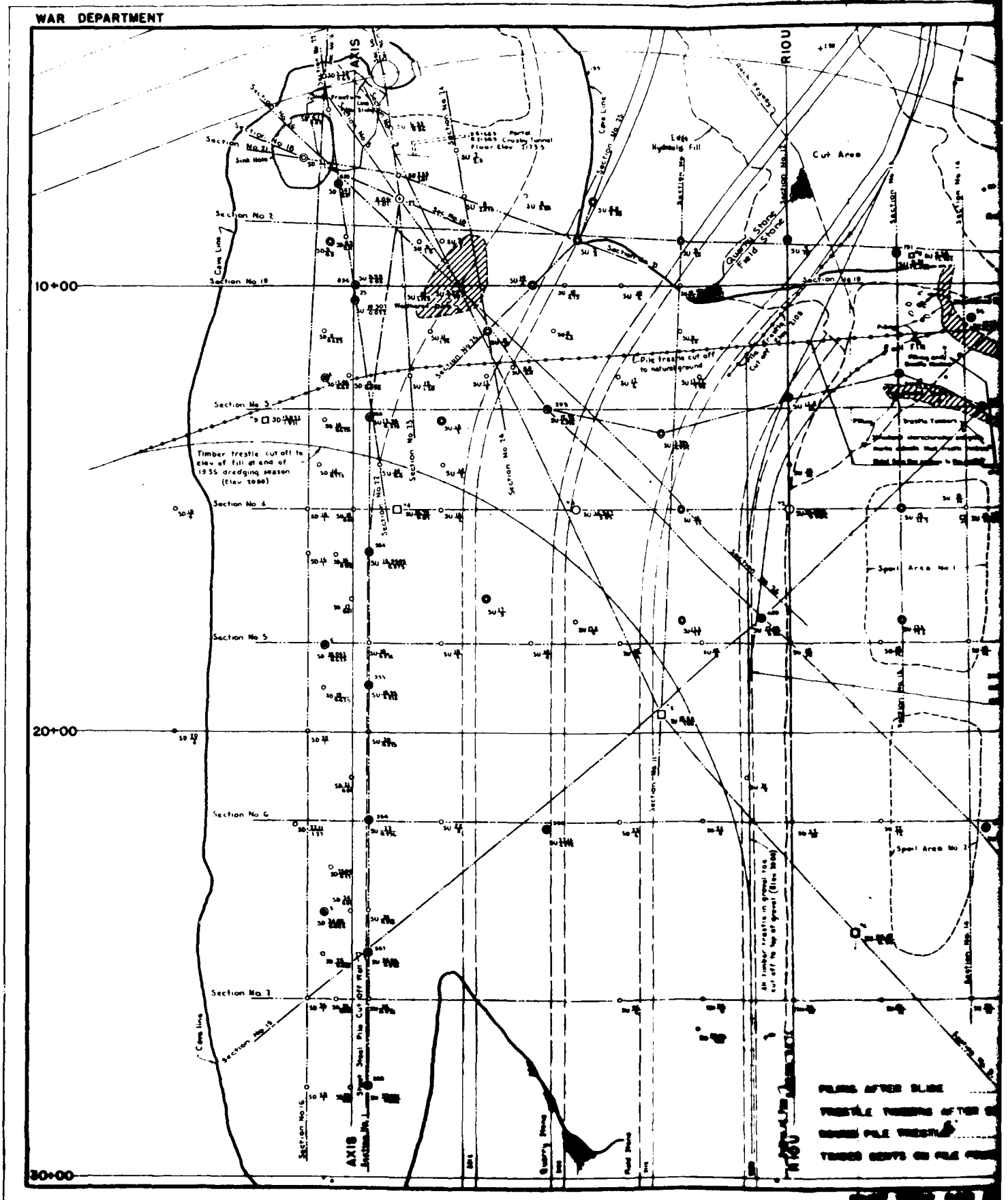
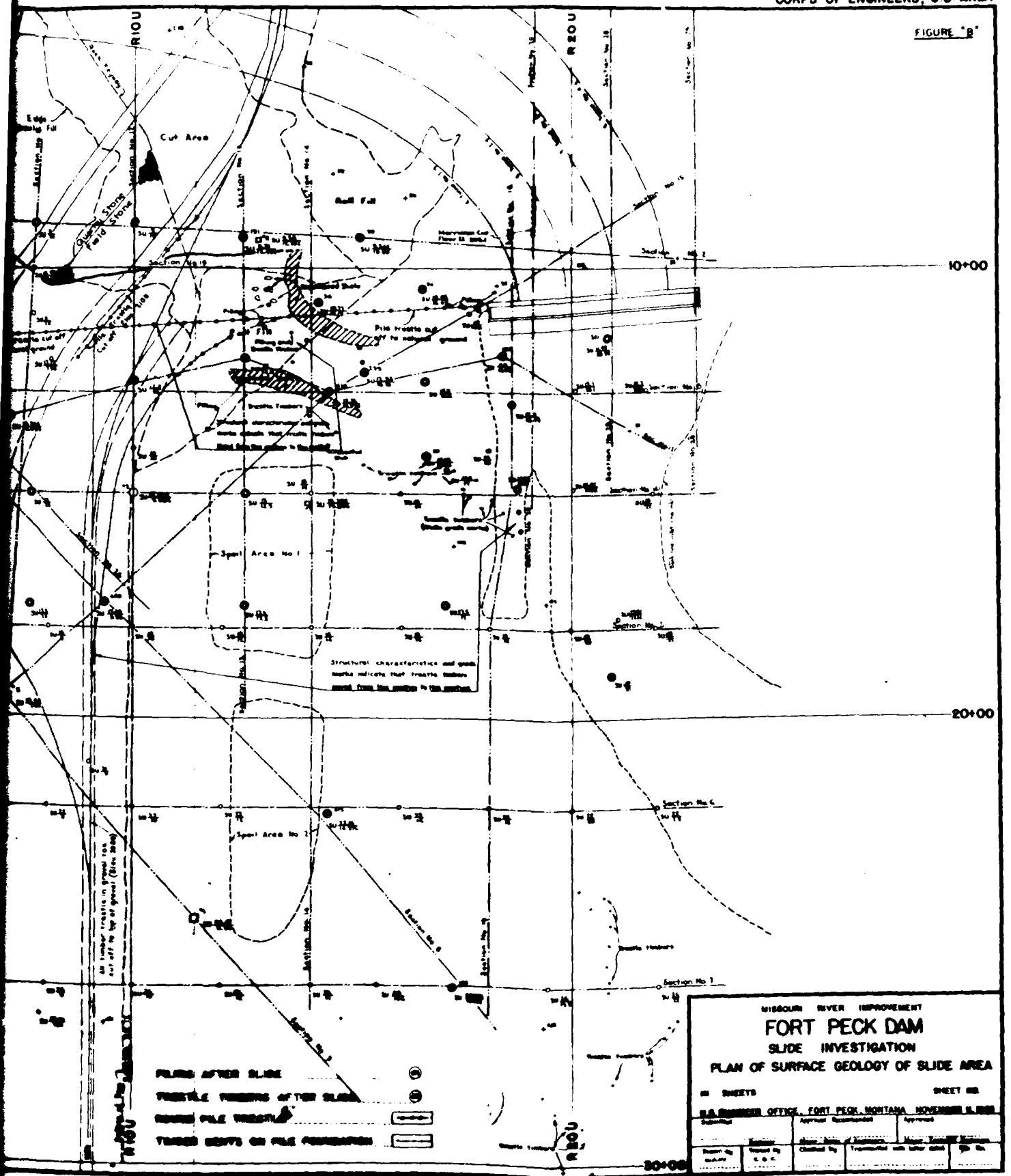

WAR DEPARTMENT
AXIS
RIOU
Cut Area
Edge Hydraulic Fill
Section No 2
Section No 3
Section No 4
Section No 5
Section No 6
Section No 7
Section No 10
Section No 11
Section No 12
Section No 13
Section No 14
Section No 15
Section No 16
Section No 17
Section No 18
Section No 19
Section No 20
Section No 21
Section No 22
Section No 23
Cave Line
10+00
20+00
30+00
Timber trestle cut off to elev of fill at end of 1935 dredging season (Elev 10.00)
Spoil Area No 1
Spoil Area No 2
Quarry Stone Field Stone
Steel Sheet Pile Cut off Wall
AXIS
RIOU

FIGURE "B"



MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

SLIDE INVESTIGATION

PLAN OF SURFACE GEOLOGY OF SLIDE AREA

SHEETS SHEET NO.

U.S. ENGINEER OFFICE, FORT PECK, MONTANA, NOVEMBER 9, 1938

Submitted	Approval Recommended	Approved

Drawn by	Traced by	Checked by	Transmitted with letter dated	Dft. No.
	C.C.C.			

A. GENERAL.

A comprehensive program of laboratory and field tests was made to determine the structural properties of the different types of materials in the damaged area, as well as in unaffected portions of the dam. These tests are grouped as follows:

Tests on overburden materials in the damaged area.

Tests on shell and transition zone material in unaffected portions of the dam.

Tests on typical foundation sands and clays.

Tests on core materials.

Tests on shale and bentonite.

These investigations are each discussed briefly.

1. <u>Overburden materials in damaged area.</u> The overburden in the damaged area included both shell and foundation sands, as well as alluvial clays and masses of core material that became intermixed during the movement.

Mechanical analyses for classification purposes were performed on overburden samples from the churn-drill holes. Overburden cores from the Calyx holes were split and photographed, and then samples for laboratory tests were cut from one of the halves. These samples, consisting of 4-inch (102 mm) cubes, were carefully selected and cut to represent typical material from each core. Tests on these included mechanical analyses, specific gravity, moisture content, and determination of the natural voids in the material. The samples were prepared in a cold-storage room, packed with dry ice to keep them frozen, and transported to the laboratory for testing.

Two series of shear tests were made on samples of overburden from Calyx hole No. 4. Plates 5-4 and 5-5 give typical results of tests on overburden materials.

2. <u>Shell and transition-zone materials in unaffected portions of dam.</u> Samples of typical shell materials were secured from undisturbed portions of the shell immediately west of the damaged area and from three test pits, located along the 2212 upstream berm, driven down to the saturation line.

A continuous photographic record was kept of the stratification of the material in the deepest test pit. On all samples, the tests included mechanical analyses, specific gravity, relative density (both wet and dry), and determination of natural voids. In addition, triaxial tests were made on disturbed and on several undisturbed samples of typical shell material from one of the test pits.

In order to check the results of critical-density tests performed on the triaxial shear machines, several series of direct-shear tests were also performed and critical density determined by the Taylor method.

[illegible] material from
[illegible] the core and the upi
[illegible] near the east
[illegible] section. On these samples,
[illegible] critical density tests, deter
natural voids, relative density tests, c
tests, and shear tests were performed.
[illegible] physical tests, a complete mineral
[illegible] was made of a typical sample of
[illegible] Plates 5-6 through 5-13 give resu
[illegible] these materials.

An experimental section of hydraulic f
structed to investigate the feasibility
ing this type of material by means of
tractors. This fill was placed in 6-in
12-inch (305 mm), 18-inch (457 mm),
(610 mm) layers to a depth of from [illegible] fee
8 feet (2.4 m). Each layer was com
three, six, or nine passes of a 95-hors
tor operating at half and full speed.

Continuous undisturbed samples were
test pits in each sampling area, and mech
ysis, specific gravity, void determinatio
ative-density tests were made on each s
results on these samples are shown on Pl
5-17.

3. <u>Foundation sands and clays.</u> A t
driven into the flood plane downstream f
in order to secure undisturbed samples
materials similar to the foundation mat
the section of the dam affected by the
ment. A continuous photographic record
the natural strata in this pit, and mecha
ses, specific gravity, void determinatio
density and critical-density tests were
this material.

Undisturbed samples of the surface cl
cured at the upstream edge of the damag
mechanical analyses, consolidation tests,
idated-shear tests were performed on th
Plates 5-13 to 5-21 show the results
foundation sands and clays.

4. <u>Core materials.</u> At a selected loc
closure section, the undamaged core o
bank, and in the center of the slide
(152 mm) drive samples were taken down
of the core. Mechanical analyses, natu
content, consolidation tests, and conso
tests were performed on samples from 10
intervals in elevation. In addition, t
tests, consolidation tests, and Att
tests were made on samples from elevat
2080. The results of typical tests on
are given on Plates 5-22 to 5-24.

5. <u>Shale and bentonite.</u> Samples

TESTS OF MATERIALS

m the transi-
upstream shell
st end of the
s, mechanical
ermination of
consolidation
In addition
alogical exam-
of shell mate-
sults of tests

fill was con-
y of compact-
of caterpillar
inch (152 mm),
and 24-inch
eet (1.8 m) to
ompacted with
rsepower trac-

e taken from
chanical anal-
ions, and rel-
sample. Test
Plates 5-14 to

test pit was
from the dam.
s of alluvial
aterials under
e earth move-
d was kept of
hanical analy-
ons, relative-
performed on

clays were se-
ged area, and
s, and consol-
these samples.
of tests on

cation in the
on the right
area, 6-inch
to the base
ural moisture
olidated-shear
-foot (3.0 m)
triaxial-shear
erberg limit
tions 2170 to
core material

of weathered

shale was taken from the Calyx holes, from the Merriman drift above the inlet portals, and from several points in the damaged area, as well as from five holes, and a test pit driven into the weathered shale downstream from the damaged section. Samples of fault-zone material were also secured from the Crosby drift near the shafts. Mechanical analyses, consolidation tests, and both consolidated and quick-shear tests were performed on these samples.

Samples of bentonite were secured from Calyx holes, the Merriman drift, the Crosby drift, and from exposed seams at other points on the right abutment. Both quick and consolidated-shear tests were performed on these samples. The coefficient of friction of bentonite on shale was also determined for some samples. The results of these tests are given on Plates 5-25 to 5-30.

In addition to the laboratory tests on the bentonite, a series of shear tests was made in the field on the two bentonite seams in the Merriman drift. These seams were lying approximately horizontal and were separated by 8 inches (203 mm) of shale. Both the normal loads and shearing loads were applied by means of hydraulic jacks. The center section of shale was confined by a steel jacket, to prevent its being crushed by the vertical load and to properly distribute the shearing forces.

B. EQUIPMENT AND PROCEDURE FOR LABORATORY TESTS.

1. Mechanical analyses. All mechanical analyses were made by the sieve and hydrometer method and were usually run wet. Samples composed of distinctly different types of material, such as sand with quantities of shale fragments or clay balls and clay samples mixed with gravel, were segregated and the percentage of each kind of material determined separately. These samples were run dry.

2. Specific-gravity determinations. Specific-gravity determinations were made on material from every sample, so that void determinations could be made more accurately. Specific-gravity determinations were made by the vacuum method on 200-gram samples.

3. Void determinations. For the purpose of determining the natural void ratio in undisturbed samples of materials from the shells, transition zones, foundation sands, and the experimental rolled hydraulic fill, 6-inch-diameter (152 mm) samples were taken in accurately calibrated cylinders 6 inches (152 mm) in length.

Void determinations of material from the frozen Calyx cores were made on the 4-inch (102 mm) cubes. The volume of the cubes was accurately determined by submerging them in a pan filled to the overflow with mercury and weighing the mercury displaced.

4. Relative-density tests. Relative-density tests were performed on all undisturbed samples of shell material, transition-zone material, and sandy material from the test pit in the flood plane below the dam, as well as on all samples from the experimental rolled hydraulic fill. The large number of relative-density tests made it necessary to construct a special device for compacting the samples to maximum density. This apparatus consisted of several pedestals, on which the tubes containing the samples were placed, the pedestals and samples being jarred up and down by cams on a motor-driven shaft. For determining the lowest possible degree of compaction, the materials were carefully deposited in glass cylinders through specially designed funnels. Relative-density tests were made on each sample in both dry and saturated condition.

5. Critical-density tests. Critical-density tests on shell materials were performed in the soils laboratory of the Graduate School of Engineering of Harvard University, at the Waterways Experiment Station, Vicksburg, Miss., and at the Fort Peck District laboratory. Tests on undisturbed samples of cohesionless materials were made at the Fort Peck laboratory.

6. Consolidation tests. All consolidation tests were made according to standard procedure in the Fort Peck type of consolidation equipment. Samples were all 5-5/8 inches (143 mm) in diameter. Samples of transition-zone material and the more pervious samples of core material were 2-1/2 inches (64 mm) in thickness, while samples of very impervious materials, such as clays and weathered shale, were 1.0 inch (25 mm) or 1-1/4 inches (32 mm) thick.

Consolidation of core and a few weathered-shale samples prior to making shear tests was accomplished in consolidation devices, although most of the bentonite and weather-shale samples were preconsolidated directly in the shear boxes.

7. Shear tests. Consolidated-shear tests on transition-zone material, weathered shale and bentonite were made in the M.I.T. shear machine, while the direct-shear tests on shell material and tests on core material were made in the Zanesville-type shear machine. All quick-shear tests were made in the Zanesville-type shear machine. The shear test samples were 4 inches (102 mm) square and 3/4-inch (10 mm) thick.

Consolidated shear tests were made by first consolidating the sample to the desired load and then adding the shearing loads in increments and waiting until movement ceased before adding additional load increments. Quick-shear tests were made with constant strain loading, the load being applied continuously, so that failure occurred within a few minutes after start of the test.

undisturbed samples of shell
one material, and sandy mate-
in the flood plane below the
samples from the experimental
The large number of relative-
necessary to construct a spe-
cting the samples to maximum
s consisted of several pedes-
s containing the samples were
and samples being jarred up
otor-driven shaft. For deter-
ible degree of compaction, the
ly deposited in glass cylin-
designed funnels. Relative-
e on each sample in both dry
.

ests. Critical-density tests
e performed in the soils lab-
te School of Engineering of
the Waterways Experiment Sta-
, and at the Fort Peck Dis-
ts on undisturbed samples of
were made at the Fort Peck

s. All consolidation tests
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olidation equipment. Samples
143 mm) in diameter. Samples
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and weathered shale, were
/4 inches (32 mm) thick.
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shear tests was accomplished
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ie samples were preconsoli-
ear boxes.
onsolidated-shear tests on
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tests on shell material and
were made in the Zanesville-
l quick-shear tests were made
shear machine. The shear
inches (102 mm) square and

ts were made by first consoli-
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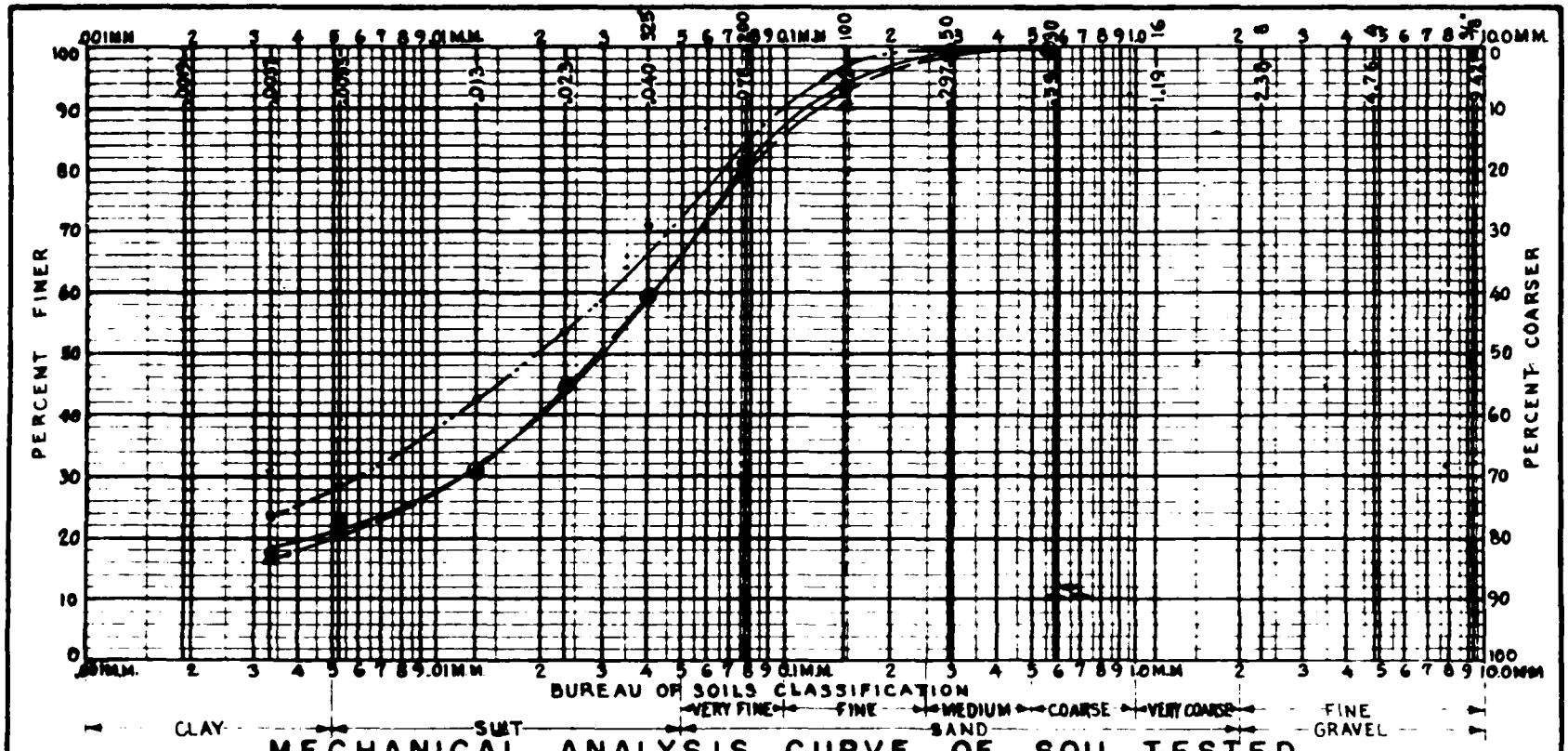
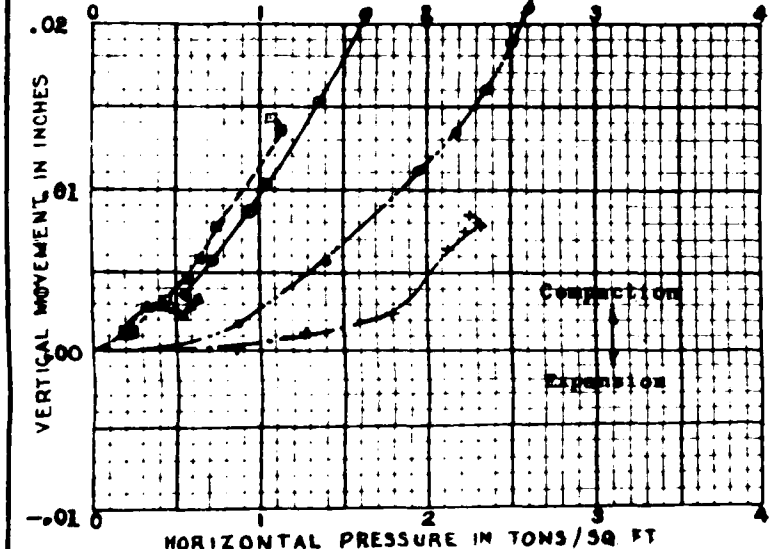
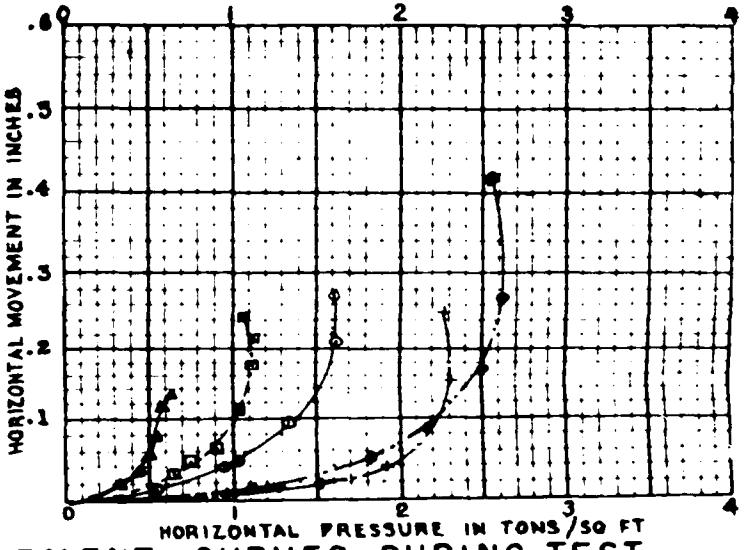
fore adding additional load
tests were made with con-
e load being applied contin-
ure occurred within a few
he test.

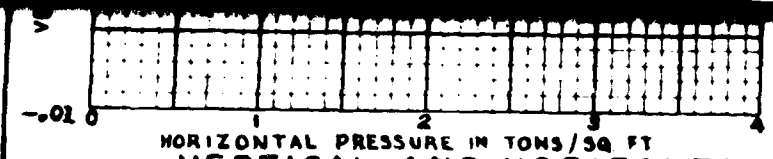


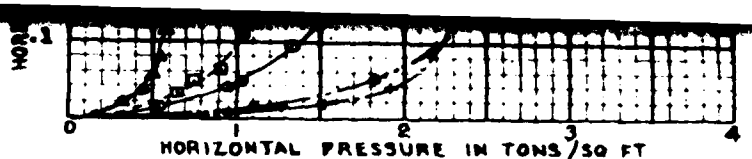
MECHANICAL ANALYSIS CURVE OF SOIL TESTED





VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



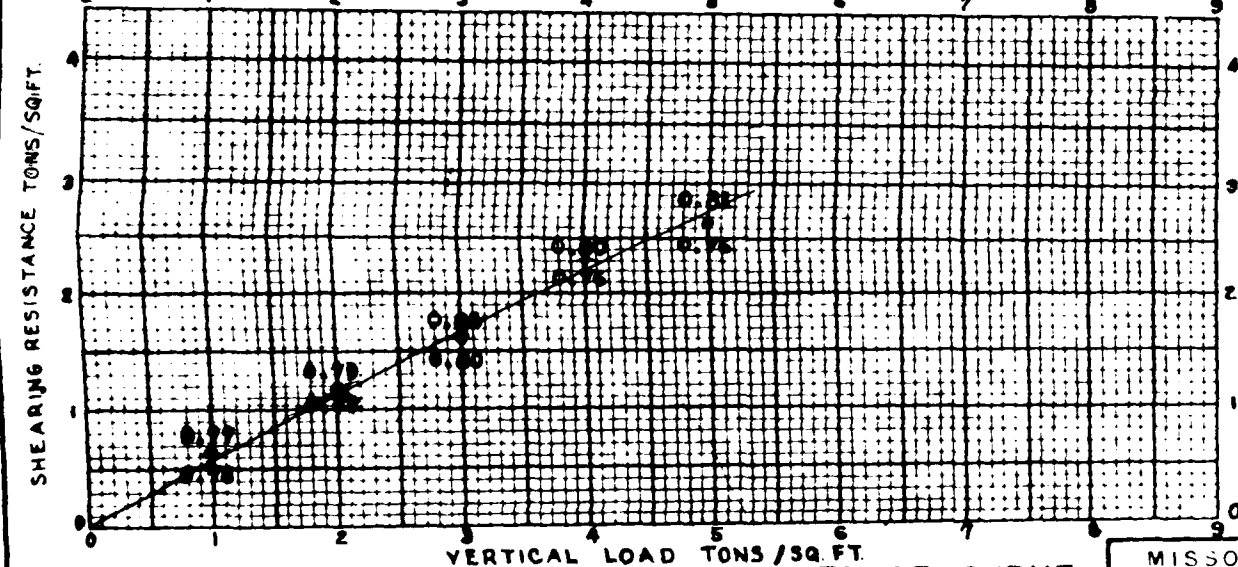


VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST

LEGEND-M.C.

Before Test ○ Undist.

After Test △



LEGEND

△——— = 1 T/sq.ft.

□——— = 2 T/sq.ft.

○——— = 3 T/sq.ft.

+——— = 4 T/sq.ft.

●——— = 5 T/sq.ft.

NORMAL LOAD-SHEARING RESISTANCE CURVE

$\tan\phi = \frac{\text{Shearing Resistance} - \text{Cohesion (Tons/Sq Ft)}}{\text{Vertical Load (Tons/Sq Ft)}}$

$= 0.552$

$\phi = 28°54'$

$c = \text{Cohesion} = 0.0$ T/sq.ft.

Notes: Undisturbed Sample
Consolidated Shear Tests
Increment Loading
Elevation 2047.0-2048.6
Cross Sectional Area of Sample 16.00 sq. in.
Initial Thickness = 1.00 inch
Sample Immersed in Water During Test.
Station 14+79.0 Range 0+87W
Section # 39

MISSOURI RIVER IMPROVEMENT
NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION

FORT PECK DAM
SLIDE INVESTIGATION
CONSOLIDATED SHEAR TESTS SERIES # 1*
MIXED MATERIAL from CALYX HOLE # 4
SECTION # 39 MONTANA 2-7-39

Drawn by	Traced by	Checked by	Approved
J L B	B J C	R J C	

Transmitted with report dated

File No

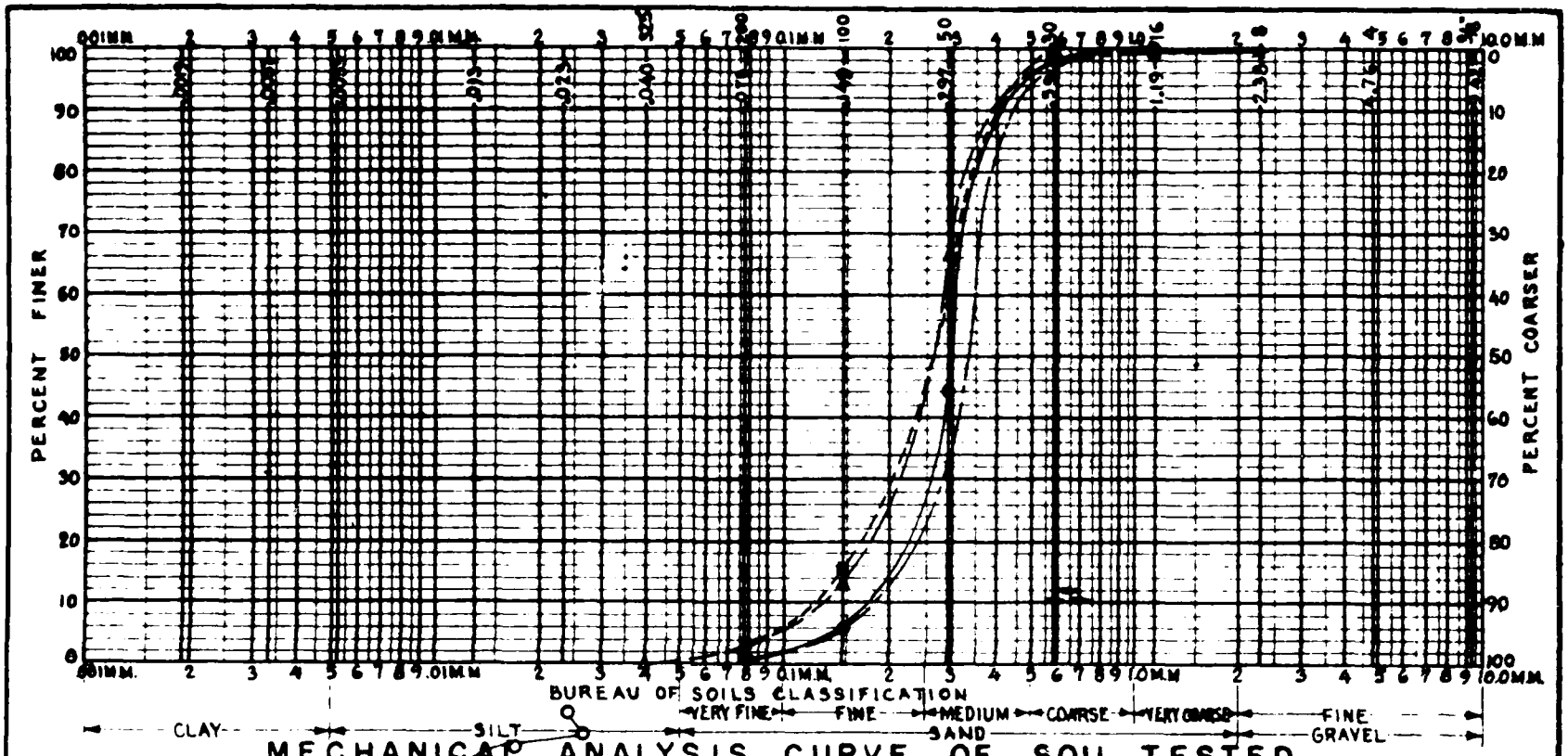
SHEET 1

CALYX HOLE NO. 4—STATION 14+79, RANGE 0+87-U

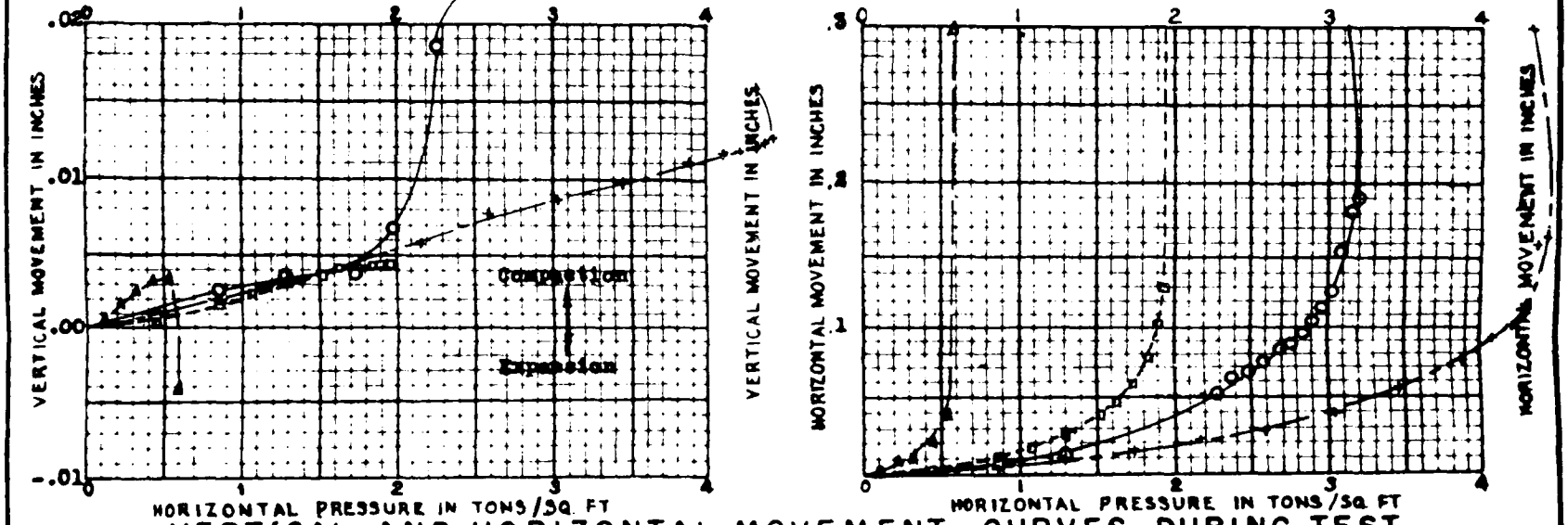
(Original sheets 2 and 3)

Core No.	Elevation top of core	Specific gravity	Moisture content, percent	Void ratio "E"	Percent of voids
1	2,124.30	2.697	25.7	0.783	43.9
2	2,122.00	2.693	20.7	.627	38.5
3	2,119.70	2.701	21.5	.676	40.3
4	2,118.30	2.689	21.5	.635	38.8
5	2,116.50	2.693	19.3	.564	36.1
6	2,114.30	2.704	20.2	.603	37.6
7	2,112.90	2.684	21.1	.624	38.4
8	2,110.72	2.691	20.6	.601	37.5
9	2,108.90	2.690	17.6	.512	33.8
10	2,107.20	2.692	18.7	.542	35.1
11	2,105.50	2.712	17.1	.509	33.7
12	2,103.88	2.682	20.7	.604	37.7
13	2,101.39	2.677	23.9	.731	42.2
14	2,099.29	2.680	22.2	.696	41.0
15	2,097.36	2.675	21.5	.665	40.0
16 [1]	2,095.20				
17	2,092.70	2.676	22.6	.670	40.1
18	2,090.60	2.678	21.6	.645	39.2
19	2,088.57	2.664	22.0	.637	38.9
20	2,086.71	2.688	22.1	.654	39.5
21	2,085.20	2.690	20.7	.619	38.2
22	2,082.70	2.665	21.2	.607	37.8
23	2,080.74	2.675	23.8	.723	42.0
24	2,078.81	2.714	19.3	.708	41.5
25	2,077.25	2.694	21.0	.644	39.2
26	2,074.94	2.669	21.6	.650	39.4
27A	2,072.90	2.685	21.6	.674	40.3
B		2.691	21.7	.685	40.6
28	2,071.43	2.680	22.4	.673	40.2
29	2,069 20.	2.703	19.2	.570	36.3
30	2,067.50	2.690	21.4	.639	39.0
31	2,064.90	2.692	21.4	.643	39.1
32	2,062.70	2.691	21.8	.648	39.3
33	2,061.00	2.697	21.7	.635	38.9
34	2,058.60	2.677	22.7	.666	39.9
35	2,056.10	2.692	21.4	.619	38.2
36	2,054.46	2.689	19.6	.568	36.2
37	2,052.20	2.688	19.1	.566	36.1
38	2,050.00	2.680	19.3	.551	35.5
39	2,048.90	2.743	26.6	.824	45.2
40	2,046.30	2.752	29.5	.880	40.5
41	2,043.60	2.697	28.3	.867	46.4
42	2,041.10	2.701	24.1	.750	42.8
43	2,039.70	2.727	22.7	.711	41.6

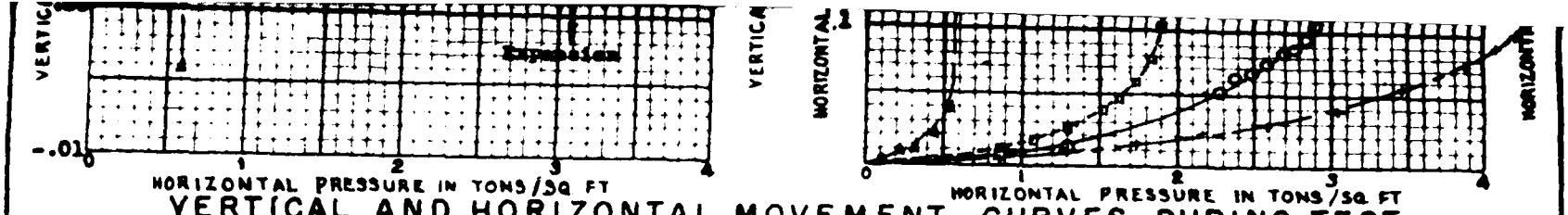
[1] First half destroyed, no sample obtained from other half of core.



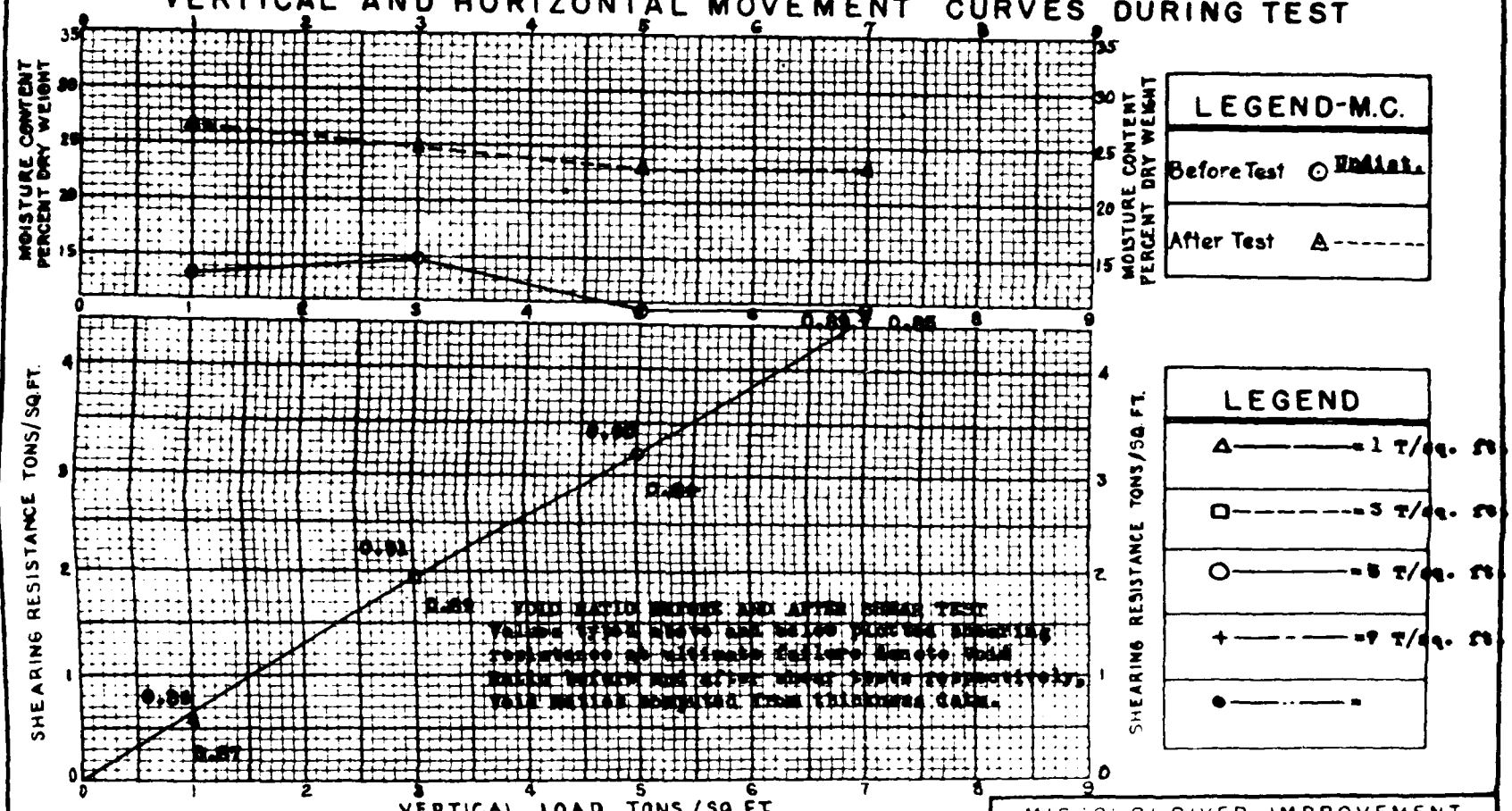
MECHANICAL ANALYSIS CURVE OF SOIL TESTED



VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



NORMAL LOAD-SHEARING RESISTANCE CURVE

tan ϕ = Shearing Resistance − Cohesion (Tons/Sq Ft) / Vertical Load (Tons/Sq Ft) = 0.640

ϕ = 32° 38'

c = Cohesion = 0.0T/sq. ft.

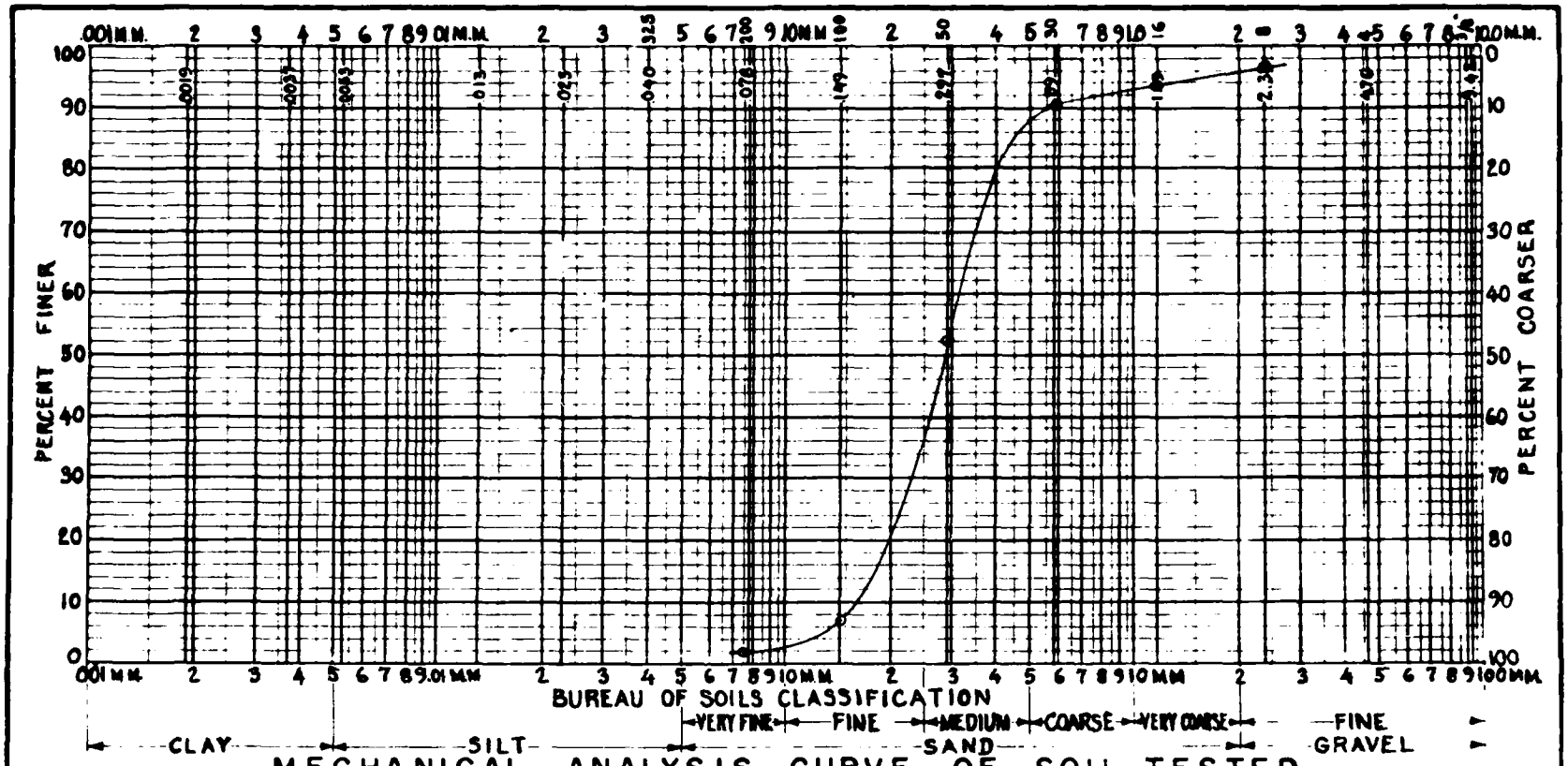
Notes:
Undisturbed Sample Test Pit #5
Consolidated Shear Tests
Increment Loading
Elevation 2242.7
Depth - 8'
Cross Sectional Area of Sample 16.00 sq. in.
Initial Thickness 0.75 inch.
Sample Immersed in Water During Test
Station 41 + 00, Range 0 + 26-U

MISSOURI RIVER IMPROVEMENT
NAVIGATION FLOOD CONTROL POWER IRRIGATION
FORT PECK DAM
SLIDE INVESTIGATION
CONSOLIDATED SHEAR TESTS SERIES #1
TRANSITION ZONE MATERIAL
U.S. ENGINEER OFFICE, FORT PECK, MONT.

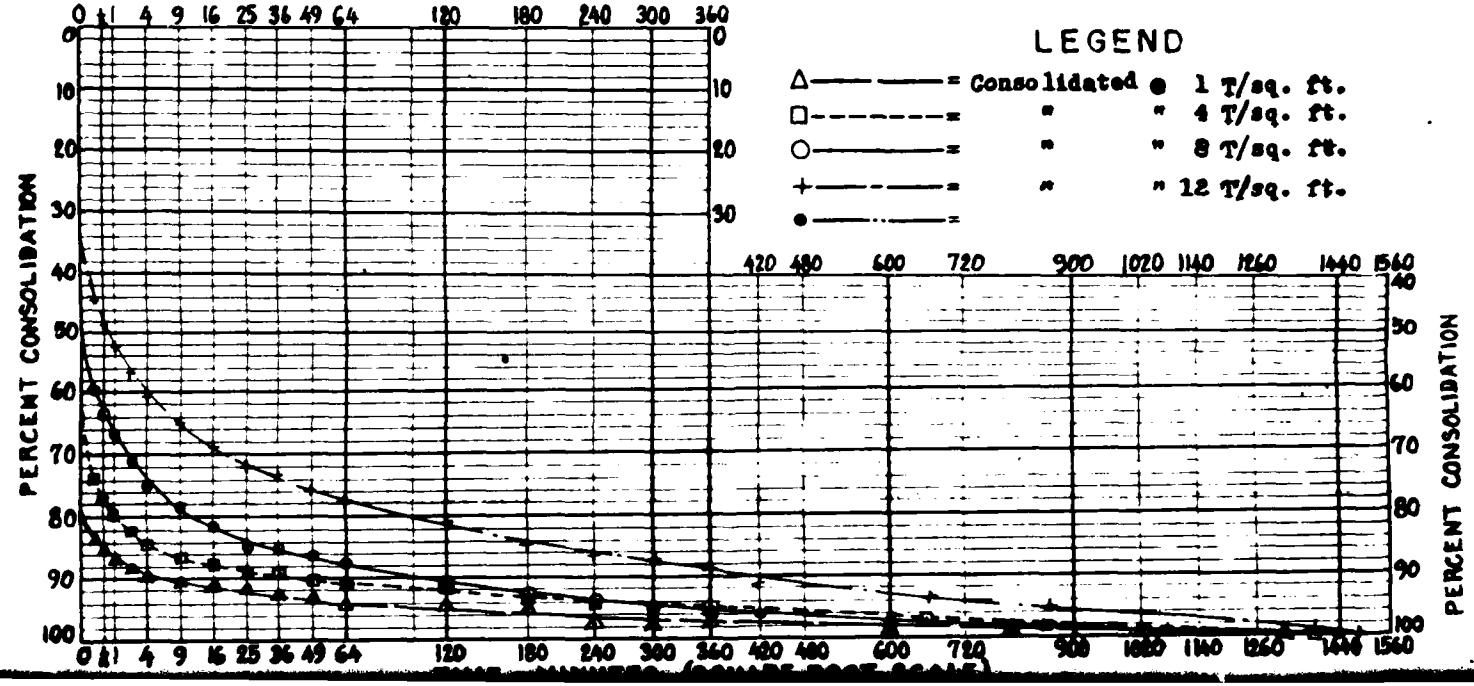
Drawn By	Traced By	Checked By	Approved
	JLB	KBC	DBD	

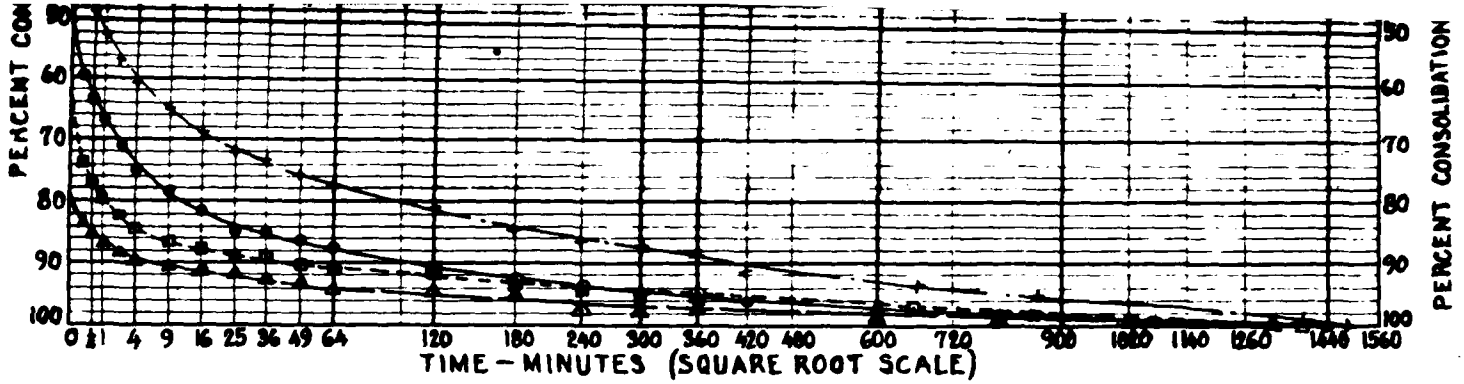
SHEET 4

FORT PECK DAM AND RESERVOIR EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 5-6

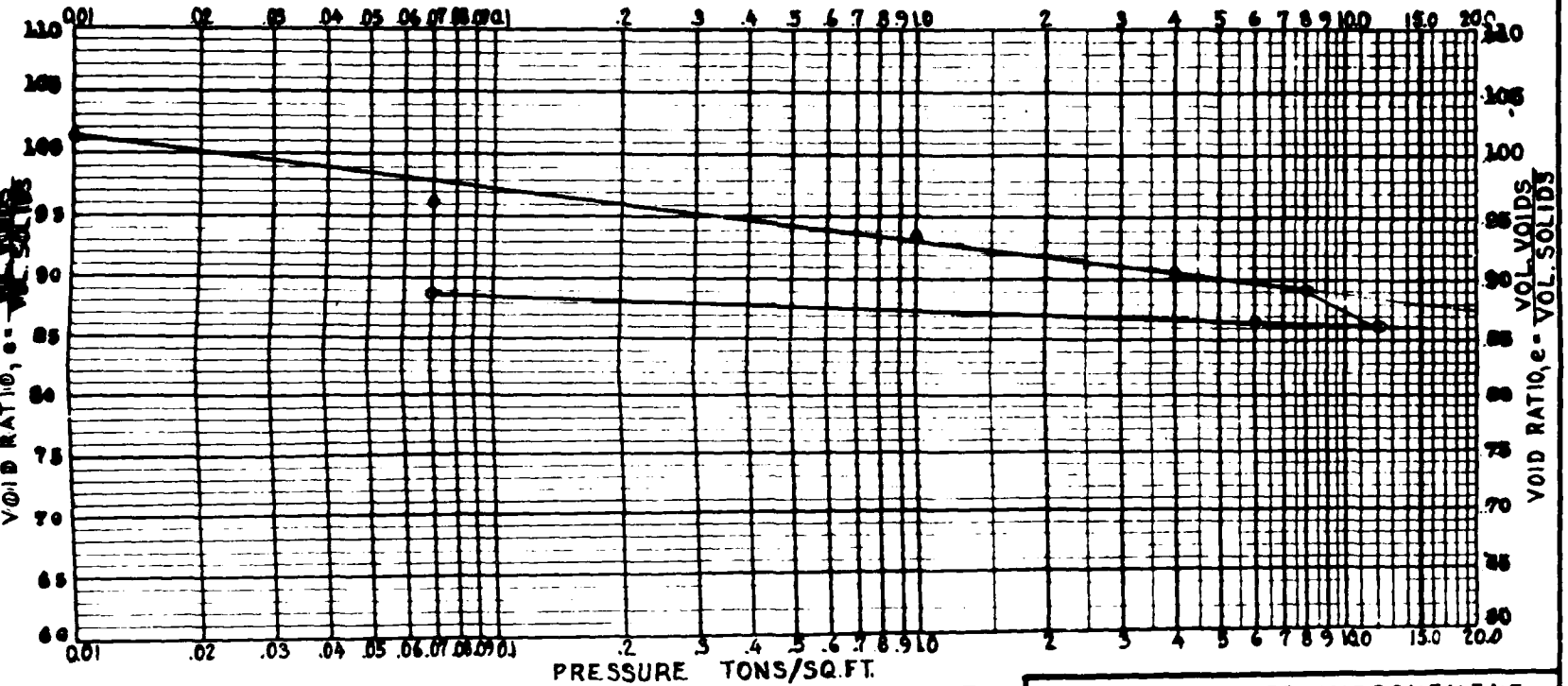


MECHANICAL ANALYSIS CURVE OF SOIL TESTED





TIME–PERCENT CONSOLIDATION CURVES



PRESSURE–VOID RATIO CURVE

Estimated Previous Consolidation = ... Tons/Sq.Ft.

VERTICAL LOAD TONS/SQ.FT.	COMPACTION PERCENT *
0.00	0.00
0.07	1.76
1.00	3.07
4.00	4.68
8.00	5.82
12.00	6.80
8.00	6.67
0.07	5.46

Undisturbed Sample Immersed in Water during test
Station 41 + 00; Range 0 + 26-U
Initial Thickness 2.50 inch
Cross Sectional Area 24.80 sq. in.
Elevation 47.2; Depth 8'

* Total compaction in percent of original height of sample.

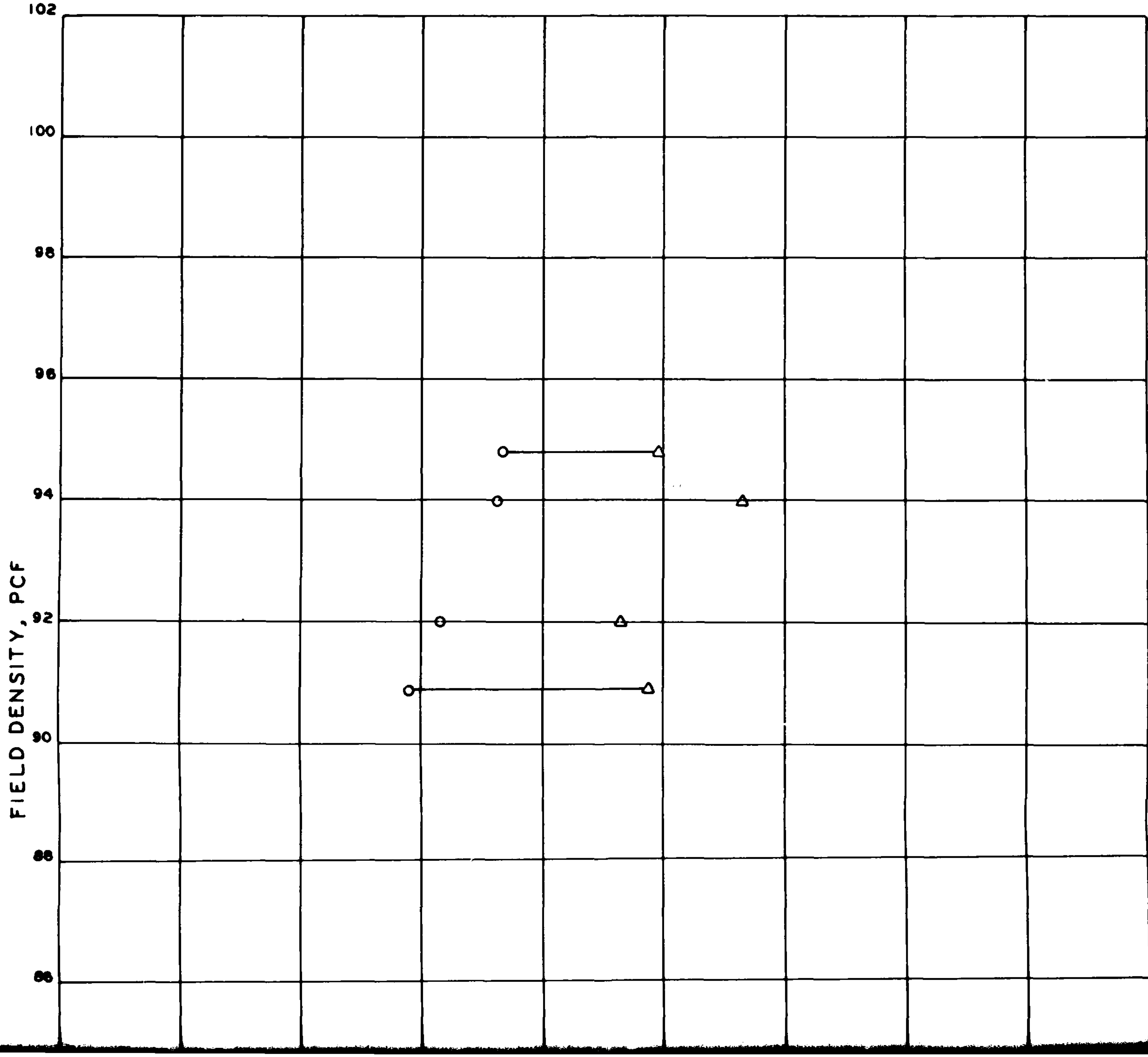
MISSOURI RIVER IMPROVEMENT
NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION

FORT PECK DAM
SLIDE INVESTIGATION
CONSOLIDATION TEST, TRANSITION MATERIAL
TEST PIT NO. 5; SERIES #1

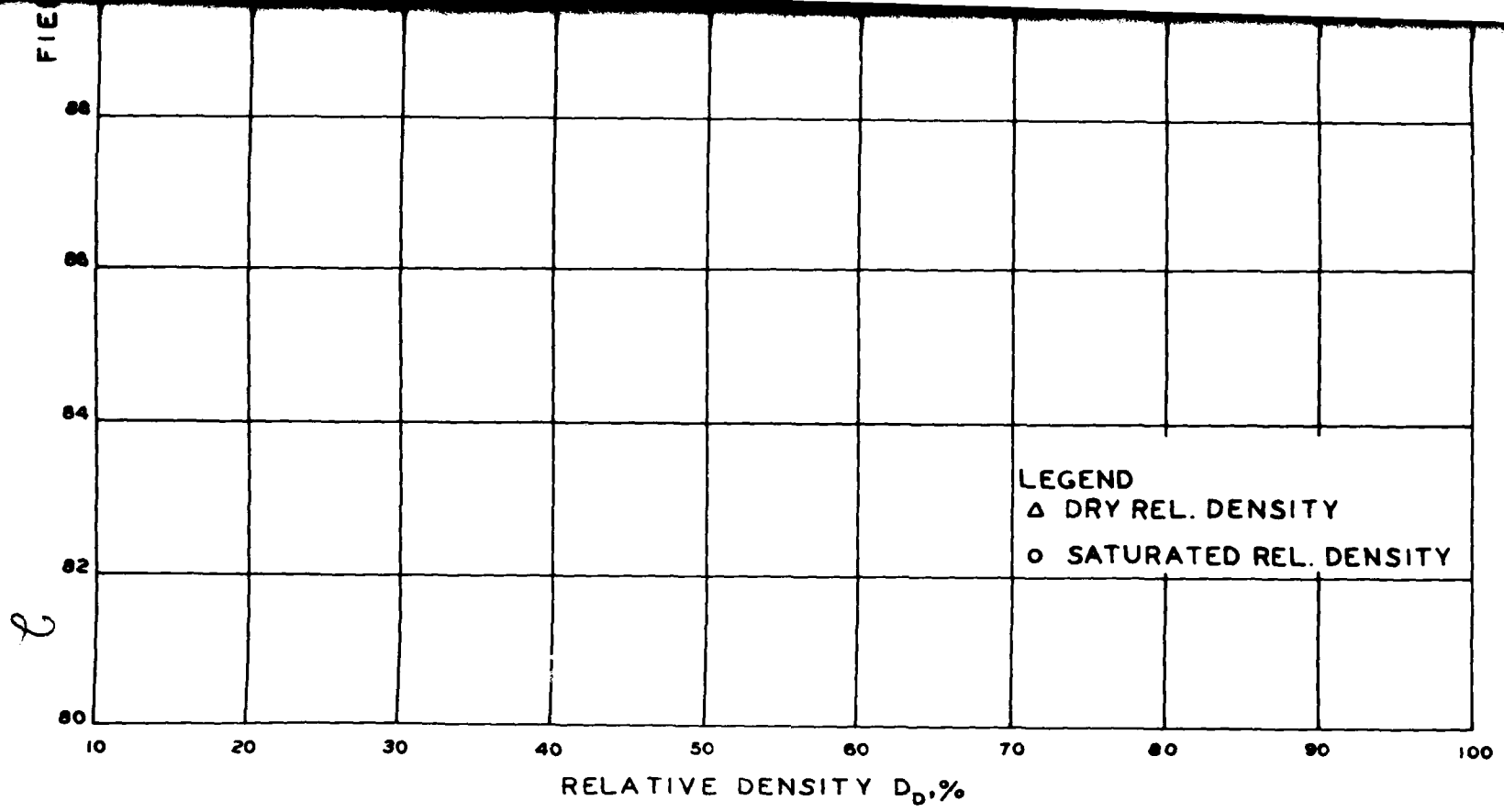
U.S. ENGINEER OFFICE, FORT PECK, MONT.

Submitted	Approval Recommended: Major, Corps of Engineers	Approved: Lt. Col., Corps of Engineers
Drawn by: DHS	Traced by: EBC	Checked by	Transmitted with report dated	File No

SHEET 5



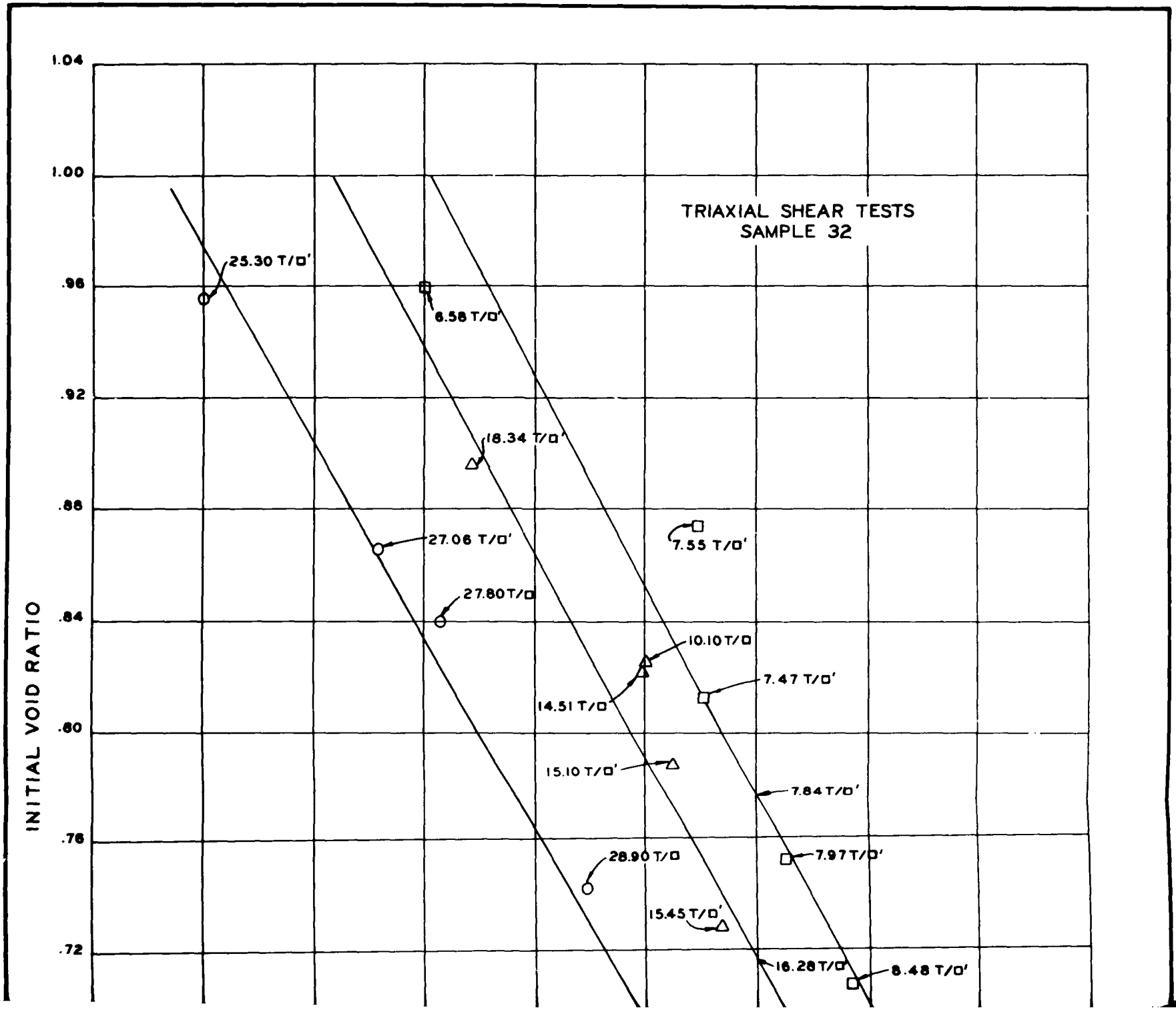
FORT PE

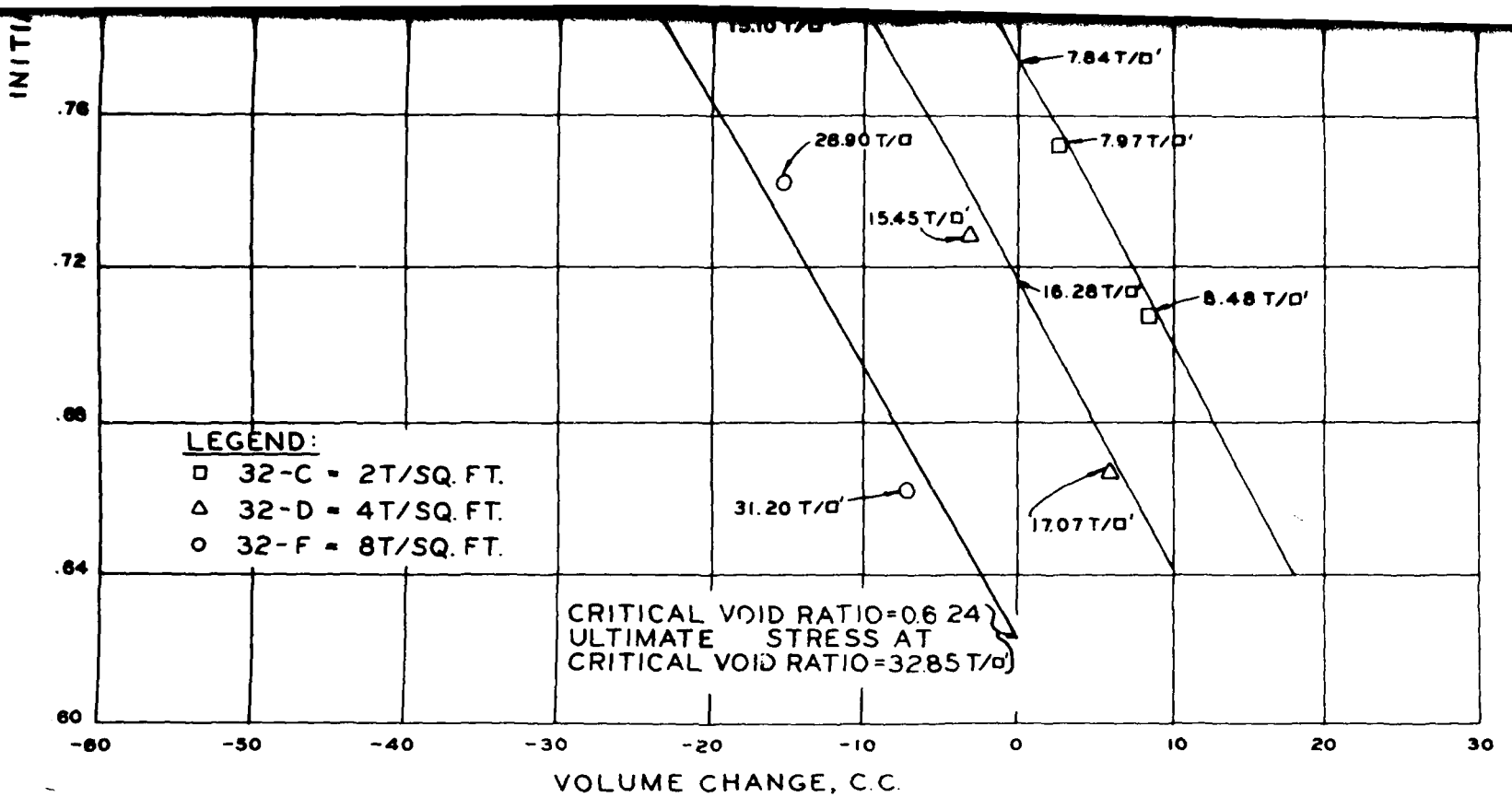


ITEM	RANGE OF VALUES
SPECIFIC GRAVITY	2.68 - 2.70
EFFECTIVE SIZE	0.11 - 0.24

FORT PECK DAM

RELATIVE DENSITY TESTS
TRANSITION ZONE MATERIAL
TEST PIT 5

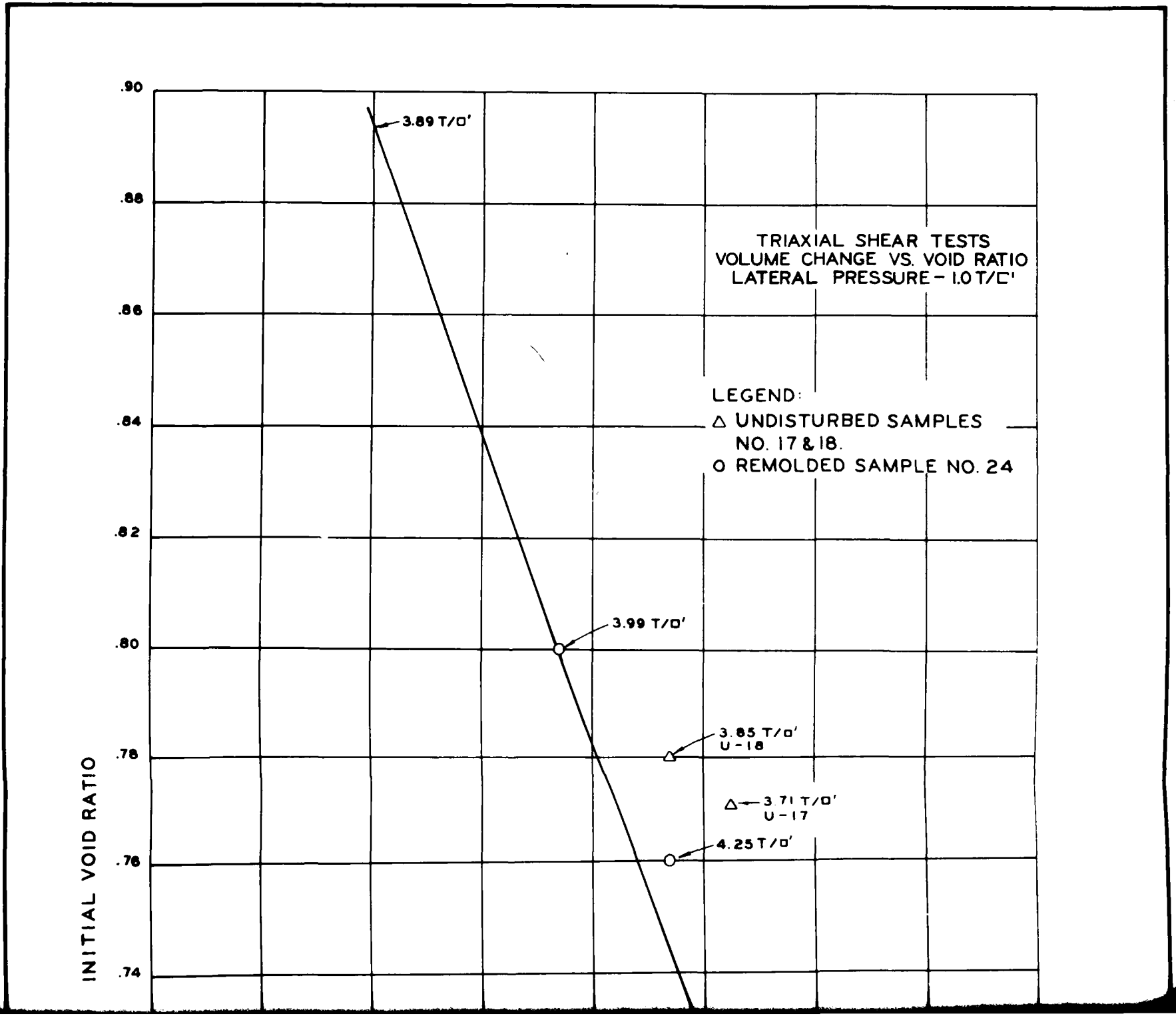

TRIAXIAL SHEAR TESTS
SAMPLE 32
INITIAL VOID RATIO
1.04
1.00
.96
.92
.88
.84
.80
.76
.72
25.30 T/□'
6.58 T/□'
18.34 T/□'
27.06 T/□'
7.55 T/□'
27.80T/□
10.10T/□
7.47 T/□'
14.51 T/□
15.10 T/□'
7.84 T/□'
28.90 T/□
7.97 T/□'
15.45 T/□'
16.28 T/□
8.48 T/□'

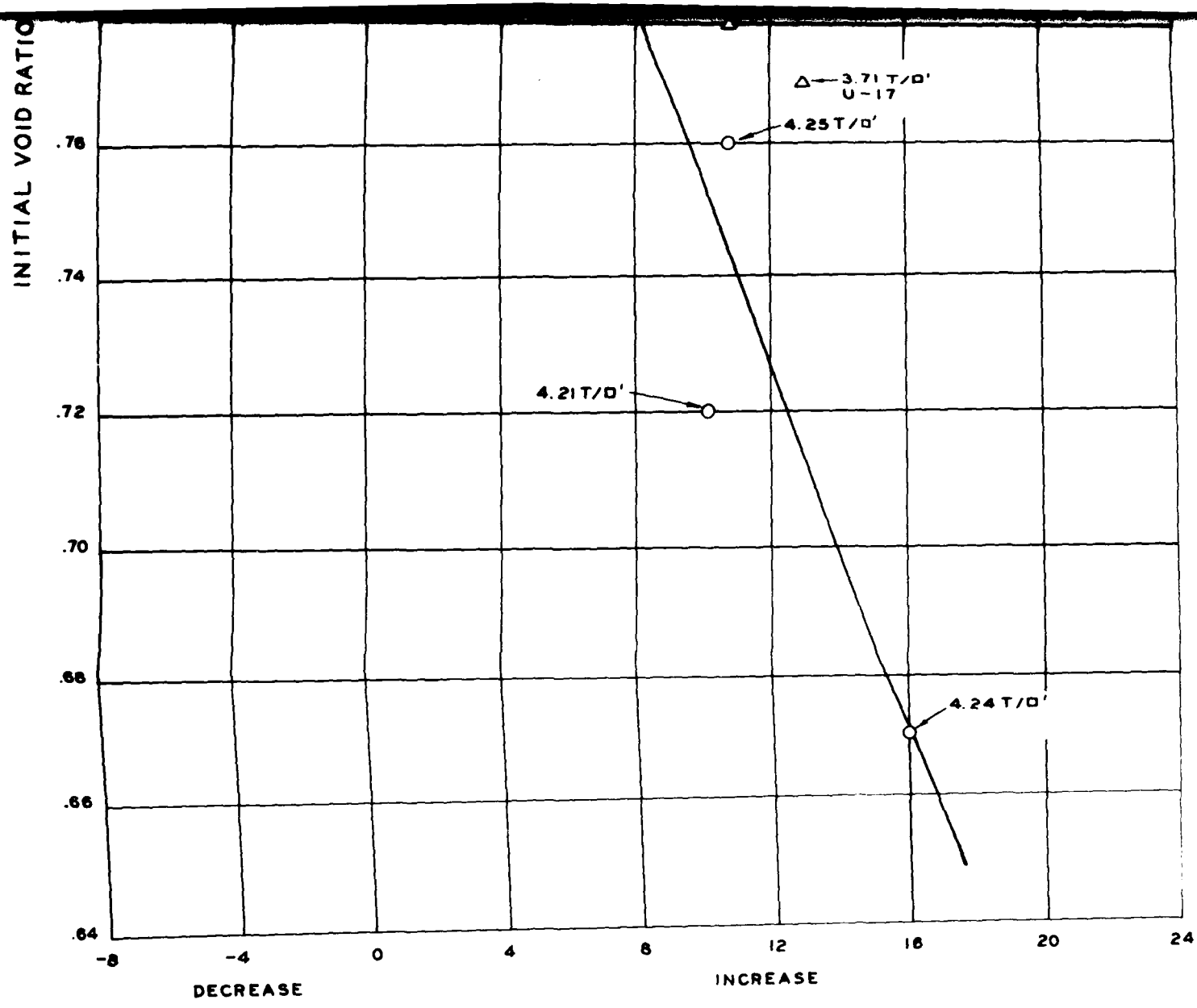


FORT PECK DAM

TYPICAL VOID RATIO CURVES FOR REMOLDED SAMPLES TRANSITION ZONE MATERIAL TEST PIT 5

☆ U.S. GOVERNMENT PRINTING OFFICE 1961 766


TRIAXIAL SHEAR TESTS
VOLUME CHANGE VS. VOID RATIO
LATERAL PRESSURE - 1.0 T/□'
LEGEND:
△ UNDISTURBED SAMPLES NO. 17 & 18.
○ REMOLDED SAMPLE NO. 24
INITIAL VOID RATIO
.90
.88
.86
.84
.82
.80
.78
.76
.74
3.89 T/□'
3.99 T/□'
3.85 T/□' U-18
3.71 T/□' U-17
4.25 T/□'

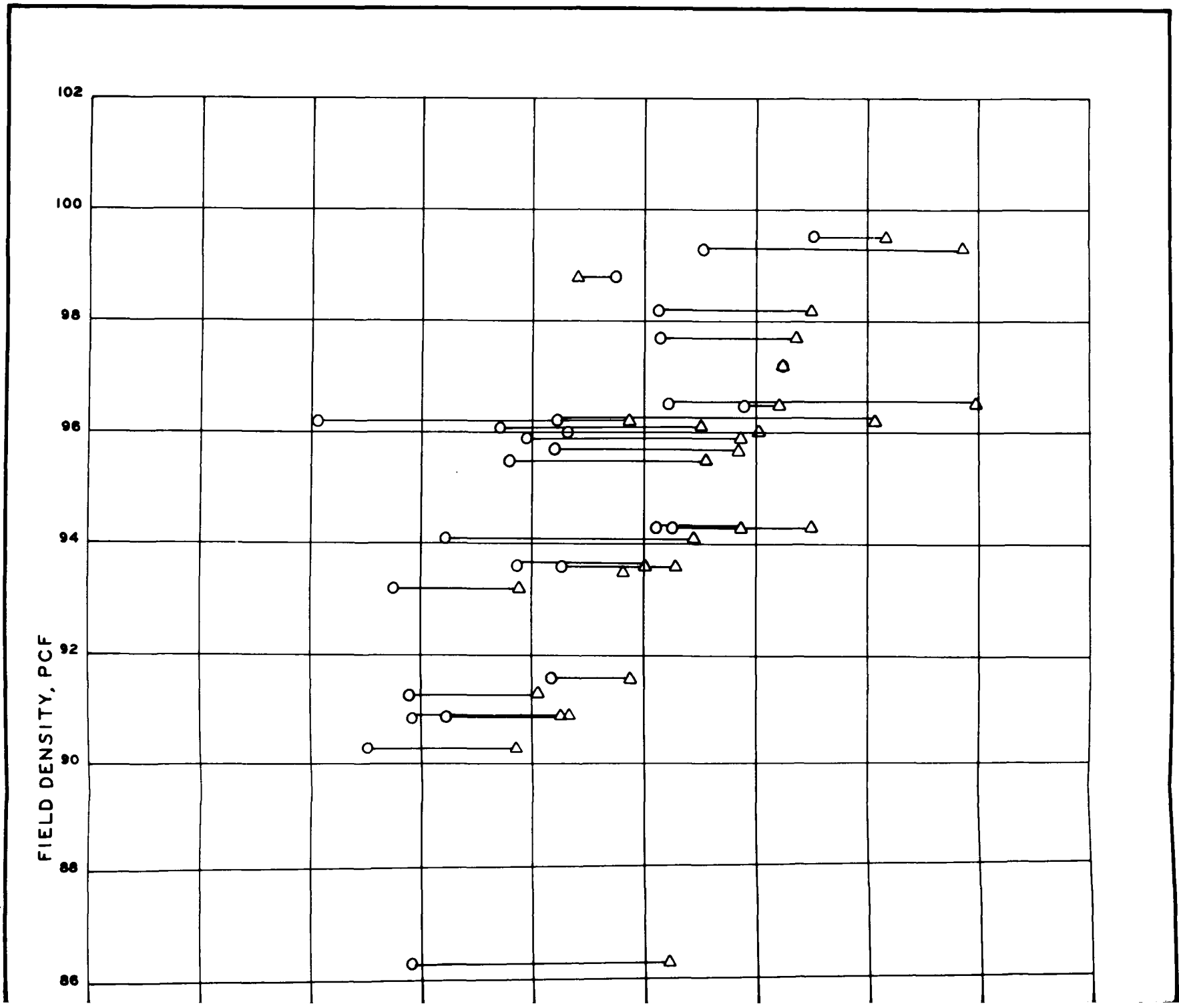


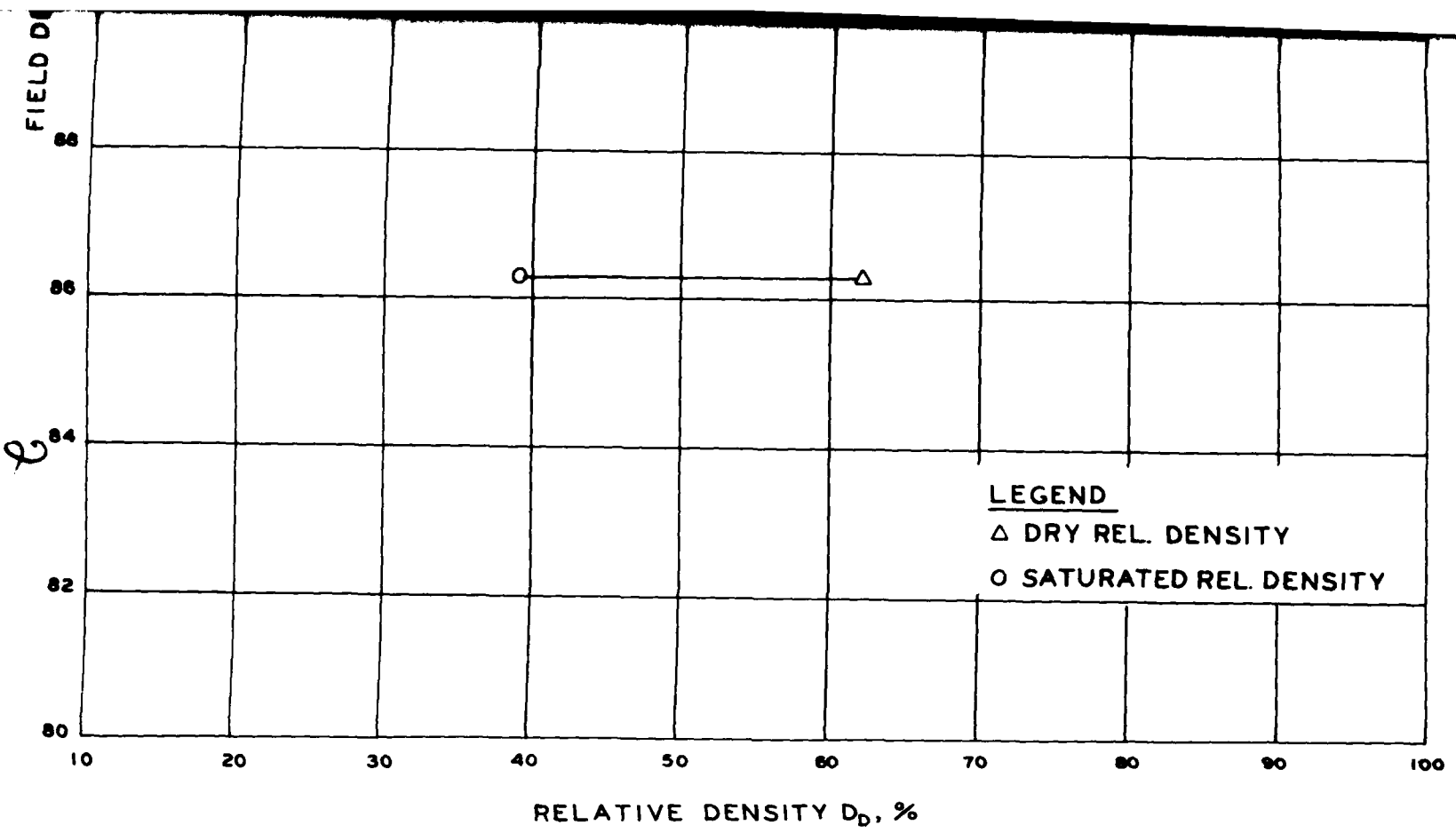
FORT PECK DAM

TYPICAL VOID RATIO CURVES FOR UNDISTURBED AND REMOLDED SAMPLES

SHELL MATERIAL
TEST PIT 3

* U.S. GOVERNMENT PRINTING OFFICE 1961-706

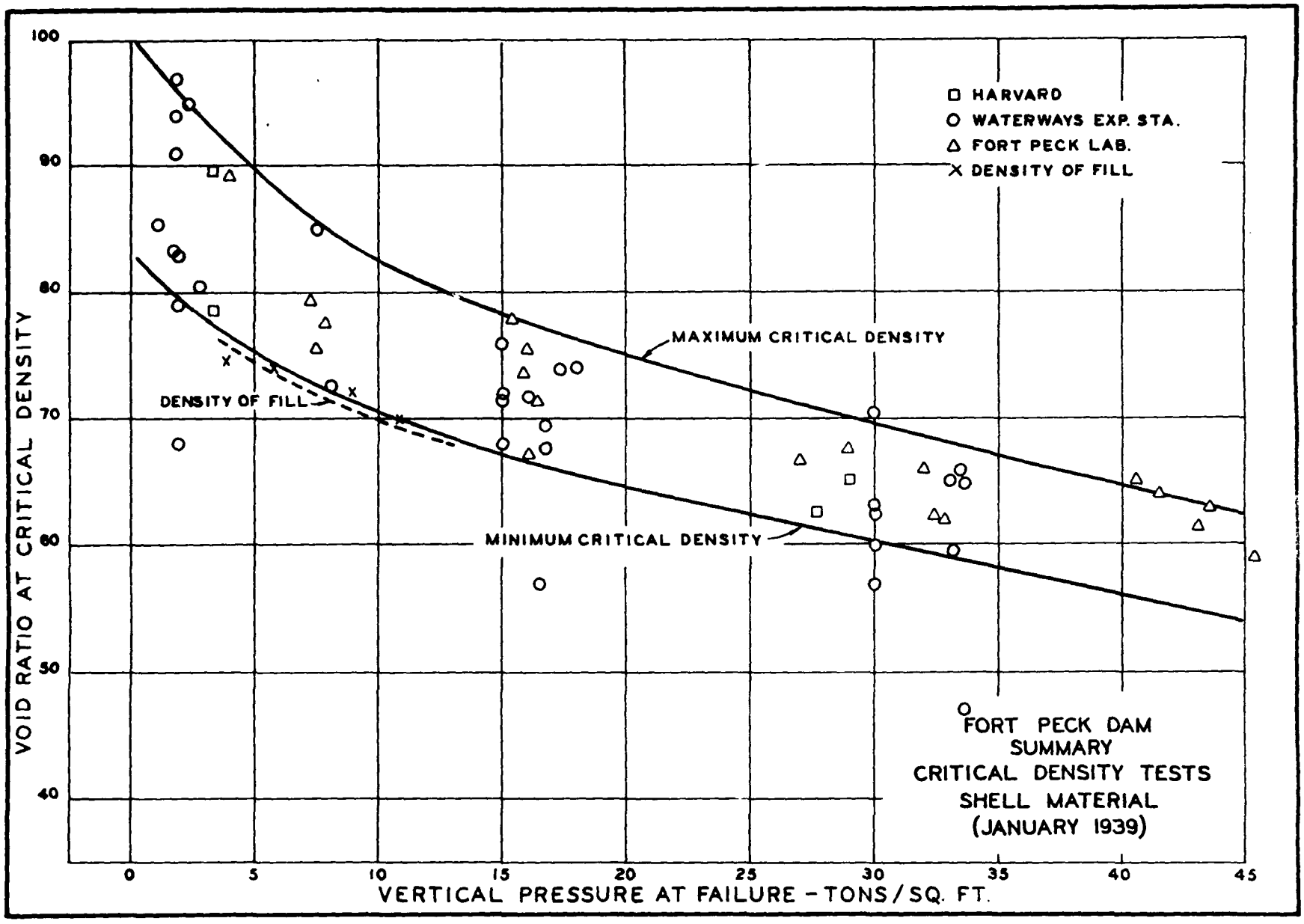

102
100
98
96
94
92
90
88
86
FIELD DENSITY, PCF



ITEM	RANGE OF VALUES
SPECIFIC GRAVITY	2.68 - 2.73
EFFECTIVE SIZE	0.11 - 0.21

FORT PECK DAM

RELATIVE DENSITY TESTS
SHELL MATERIAL
TEST PIT 1


HARVARD
WATERWAYS EXP. STA.
FORT PECK LAB.
DENSITY OF FILL
MAXIMUM CRITICAL DENSITY
DENSITY OF FILL
MINIMUM CRITICAL DENSITY
FORT PECK DAM
SUMMARY
CRITICAL DENSITY TESTS
SHELL MATERIAL
(JANUARY 1939)
VOID RATIO AT CRITICAL DENSITY
VERTICAL PRESSURE AT FAILURE - TONS/SQ. FT.
100
90
80
70
60
50
40
0
5
10
15
20
25
30
35
40
45

PETROGRAPHIC ANALYSIS OF SAND SAMPLE, FORT PECK, NO. 1-A

General Statement. The usual procedure in the petrographic analysis of a sand is to separate the sample into two fractions on the basis of the specific gravity of the constituents. The "light" fraction (sp. gr. less than 2.84) contains most of the material, but the "heavy" fraction (sp. gr. greater than 2.84) contains a greater variety of minerals. The percentage of each fraction is determined by weight, but the percentages of minerals and other constituents within each fraction is determined by counting grains, and hence is a frequency percentage, not a weight percentage. This procedure does not introduce any great error if the grains are fairly uniform in size, but in the present sample they are not. The grains range from fine gravel to clay size, so that frequency percentages determined on the whole sample would place an unwarranted emphasis on the minute grains, which are numerically abundant but constitute only a small percentage by weight of the whole sample. Since the various size grades of this sample show marked differences in composition, this factor is important, especially in the case of "light" fraction, which constitutes 97 percent of the sample. To eliminate this error it would be necessary to analyse each size grade, then multiply the percentage of each mineral in each size grade by the weight percentage of the size grade as determined by mechanical analysis (sieving). Totalling the products for each mineral would give its weight percentage in the sample as a whole, except for minor errors resulting from differences in the specific gravities of the minerals. This procedure, however, greatly increases the time required for an analysis, and hence would increase its cost considerably over the price quoted in the contract for analysis of this sample. I have therefore done the next best thing - analysed the "light" fraction of the two size grades which contain the greatest amount of the sample, the 35 to 48 mesh and 48 to 65 mesh grades. I have also included an analysis of the coarsest grade (8 to 14 mesh) and an estimate of the composition of the finest material (passing the 200 mesh sieve). The "heavy" fraction constitutes such a small percentage (3 percent) of the whole sample that this procedure was not considered necessary.

Composition of the "light" fraction. The "light" fraction comprises 0.97 percent of the sample. The two size grades containing most of the material have the following composition:

Composition of the "light" fraction of the 35 to 48 and 48 to 65 mesh size grades.

(Frequency percentages on the basis of 100 percent)

	35-48 size grade	48-65 size grade
Rock grains:		
Chert	14	15
Shale	11	10
Sandstone and siltstone	6	3
Volcanic rocks	11	10
Granitic rocks	3	2
	45	40
Quartz	38	45
Feldspars:		
Plagioclase	10	8
Microcline	3	3
Orthoclase	2	2
Sanidine	P	P
	15	13
Others:		
Muscovite	P	P
Chlorite	P	P
Calcite	P	1
Volcanic glass	1	P
Carbonaceous material (lignite)	P	P
	2	2

NOTE - P = Present in amounts less than 1 percent.

The coarsest size grade (8-14 mesh), has the following composition: Rock grains 82 percent (chert 2 percent, shale 52 percent, sandstone and siltstone 26 percent, volcanic rocks 1 percent, granitic rocks 1 percent), quartz 10 percent, feldspars 5 percent, calcite 2 percent, volcanic glass and lignite in traces.

Percentages were not determined on the finest material (passing the 200 mesh), but inspection indicates that it has approximately the following composition: calcite 15-20 percent, clay mineral aggregates 15-20 percent, quartz and feldspar (together) 55-65 percent, others about 5 percent.

Composition of the "heavy" fraction. The "heavy" fraction constitutes 3 percent of the sample. About half of this material consists of the iron oxides, limonite and hematite. These occur as grains up to 3 mm in diameter, and their presence in such abundance so interfered with determination of the other

t it was found necessary to remove them the "heavy fraction in 50 percent HCl es. Of the material not removed, au- far the most common mineral, occurring to 3 mm in length. Since most of the minerals are much smaller, the weight f augite is considerably higher than percentage.

of the "heavy fraction from the whole

percent HCl 50% by wt.
monite and hematite, with 1 to 2 per- the carbonates dolomite and siderite, 1 percent apatite.
50 percent HCl.
percentages on basis of 100 percent.)
is:

	14
	3
	3
	P
	2
ornblende	P
hornblende	4
blende	7
	P
	4

luding some aegirine-augite and

	36
	4

Composition of the "heavy" fraction from the whole sample, continued.

Others:

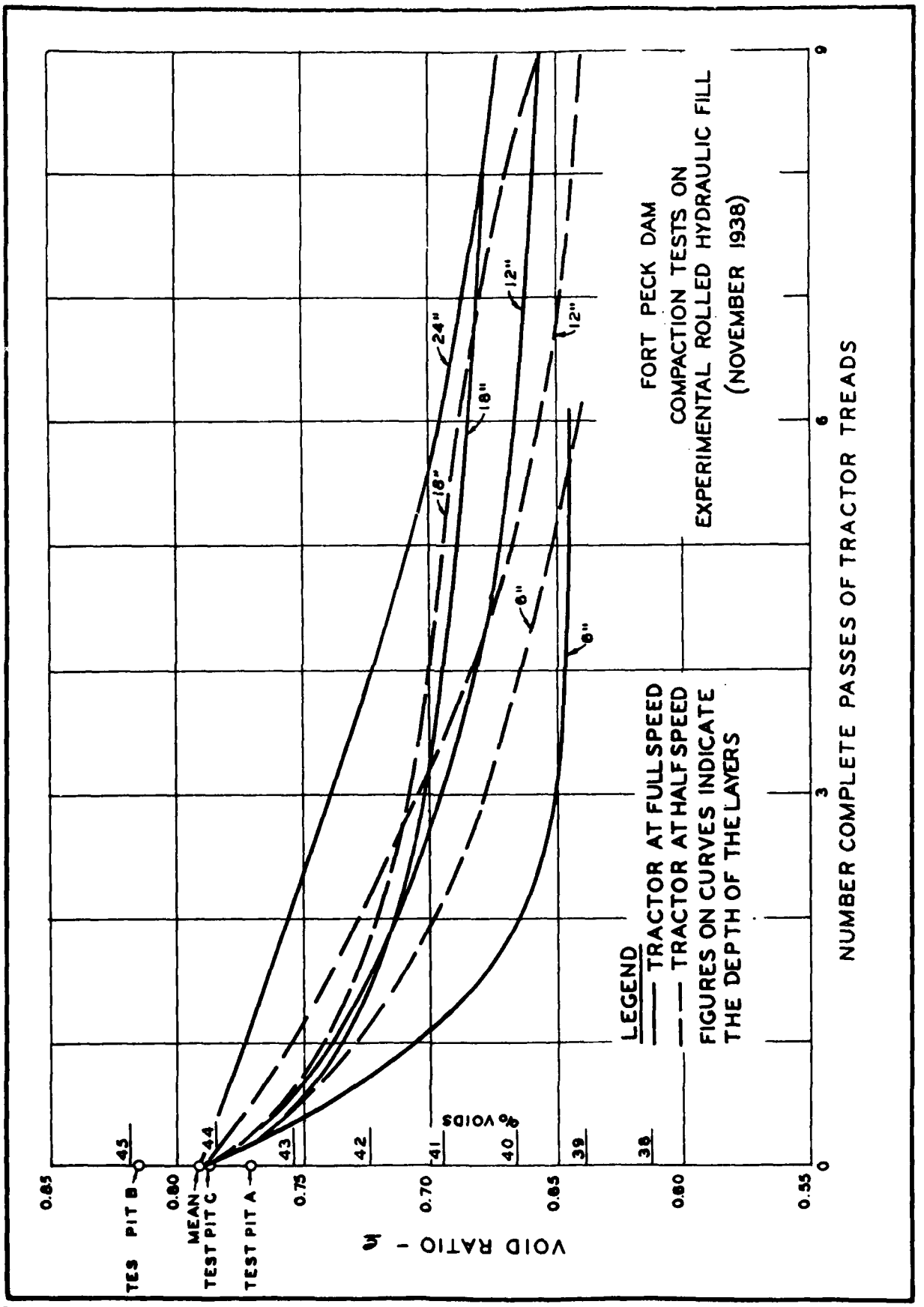
Allanite	P
Barite	8
Collophane	P
Epidote	9
Garnet	6
Rutile	P
Staurolite	P
Titanite	2
Tourmaline	P
Zircon	3
Zoisite	P

Note - P = Present in amounts less than 1 percent.

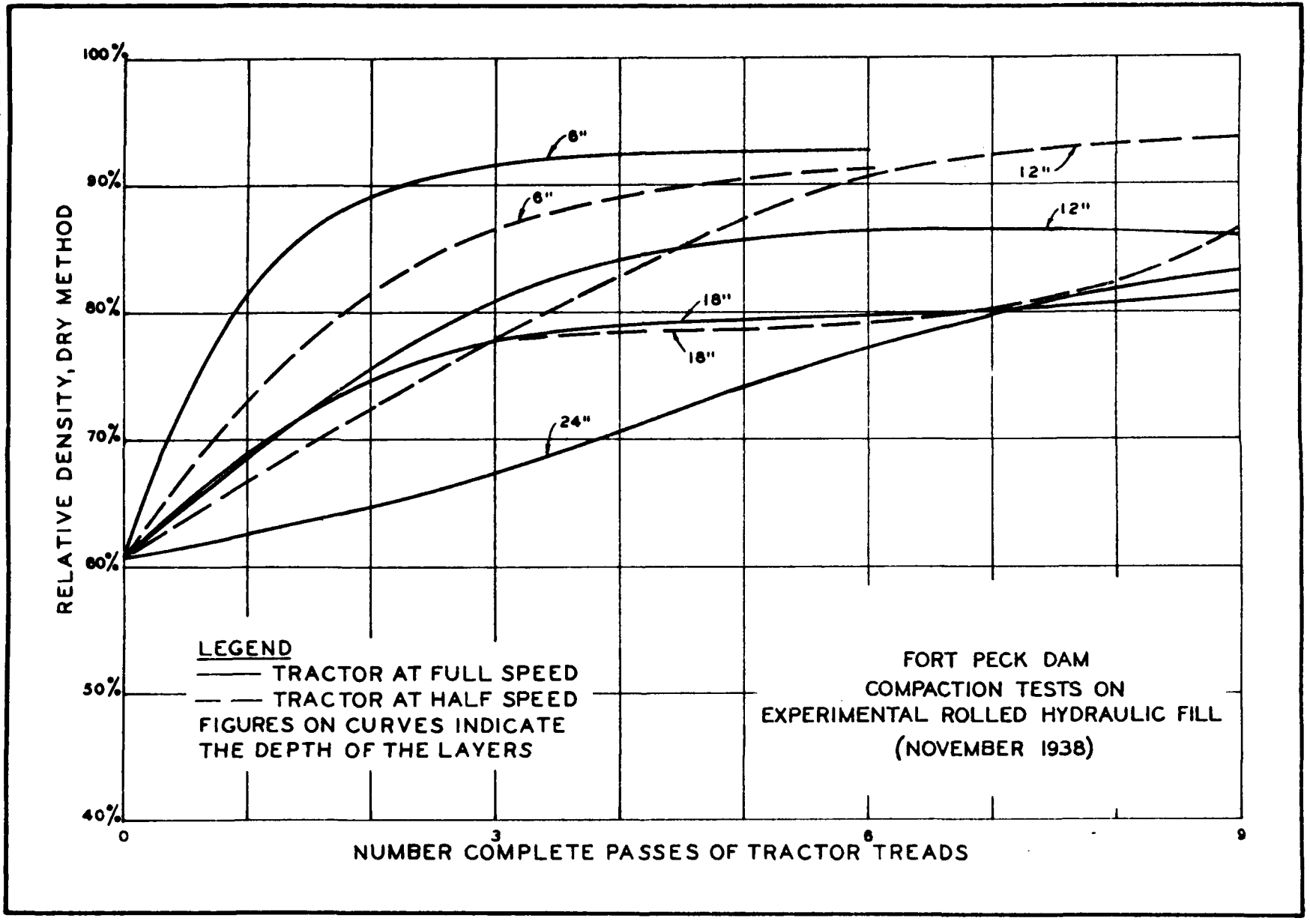
Conclusions. The abundance of shale fragments in the coarser size grades indicates contribution of this material from a nearby source, as these fragments could not withstand prolonged transportation. The other elements in the sample have been derived chiefly from intermediate to basic volcanic rocks (andesites and basalts), as indicated by the abundance of augite as well as of fragments of these rocks, and from previously formed sedimentary rocks. Other igneous rocks, particularly granitic types, have contributed some material, while metamorphic rock types furnished very little.

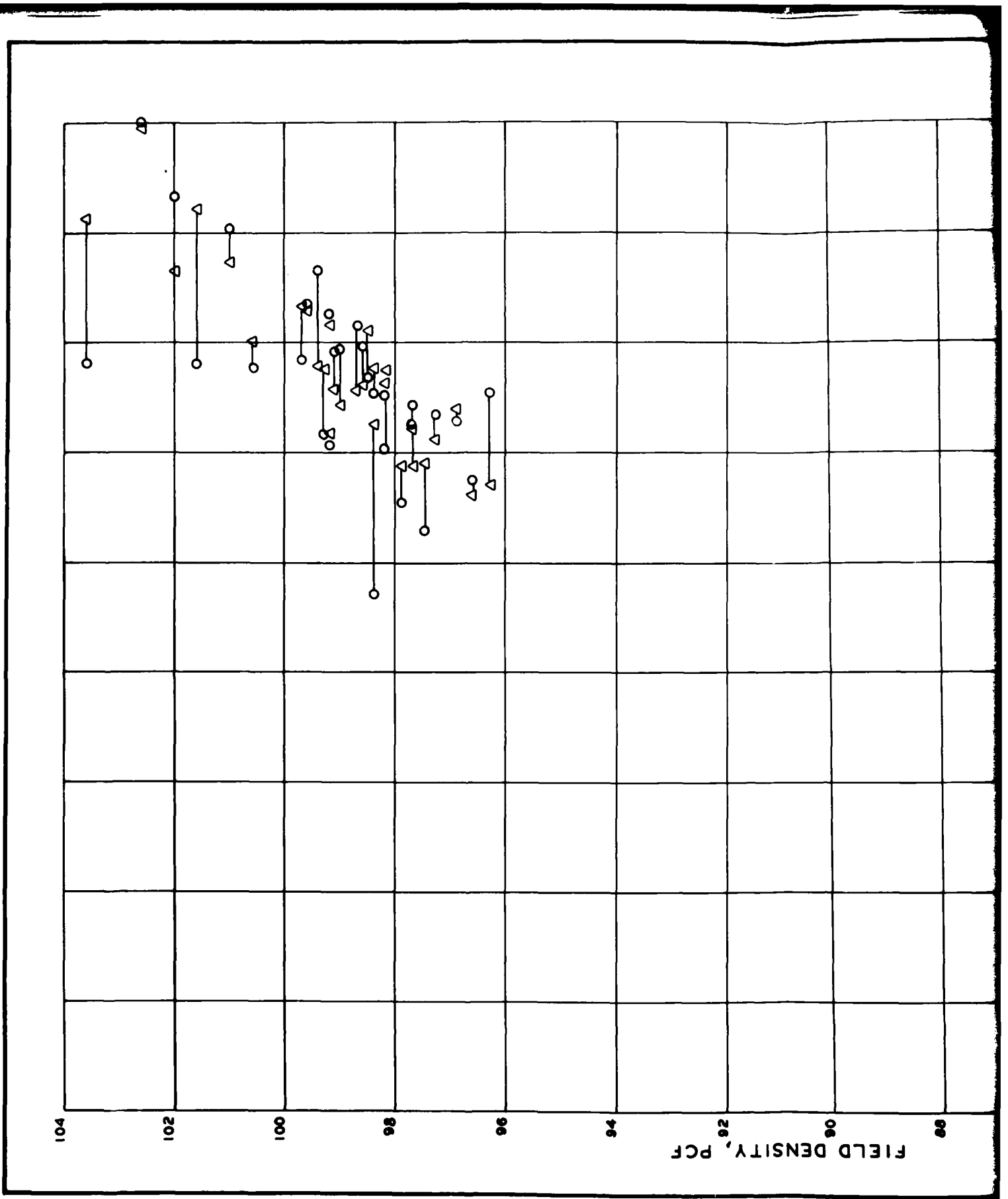
[s] R. DANA RUSSELL.

2

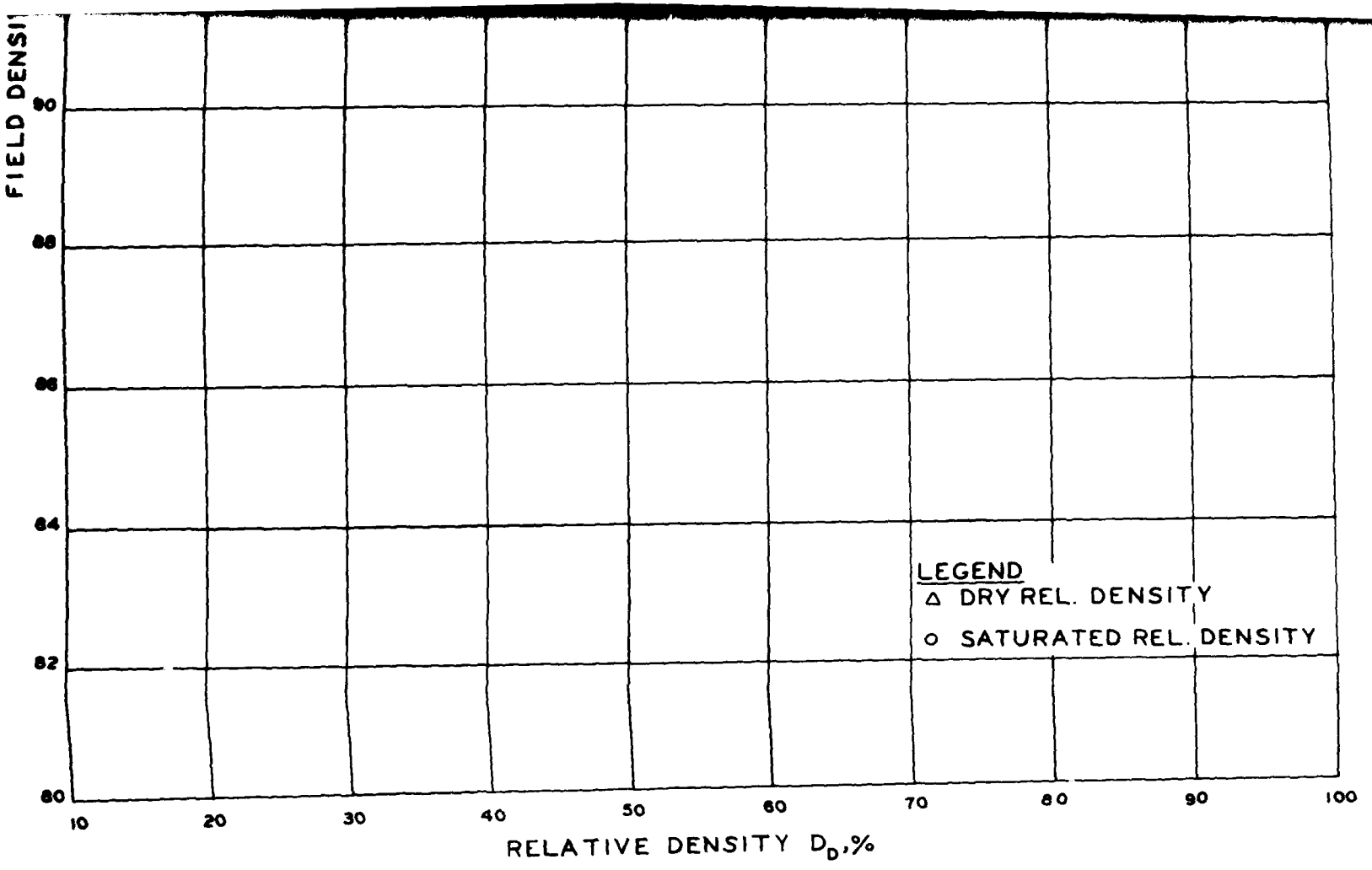


FORT PECK DAM AND RESERVOIR EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 5-14


RELATIVE DENSITY, DRY METHOD
100%
90%
80%
70%
60%
50%
40%
0
3
6
9
NUMBER COMPLETE PASSES OF TRACTOR TREADS
6"
6"
12"
12"
18"
18"
24"
LEGEND
TRACTOR AT FULL SPEED
TRACTOR AT HALF SPEED
FIGURES ON CURVES INDICATE THE DEPTH OF THE LAYERS
FORT PECK DAM
COMPACTION TESTS ON
EXPERIMENTAL ROLLED HYDRAULIC FILL
(NOVEMBER 1938)



FORT PE

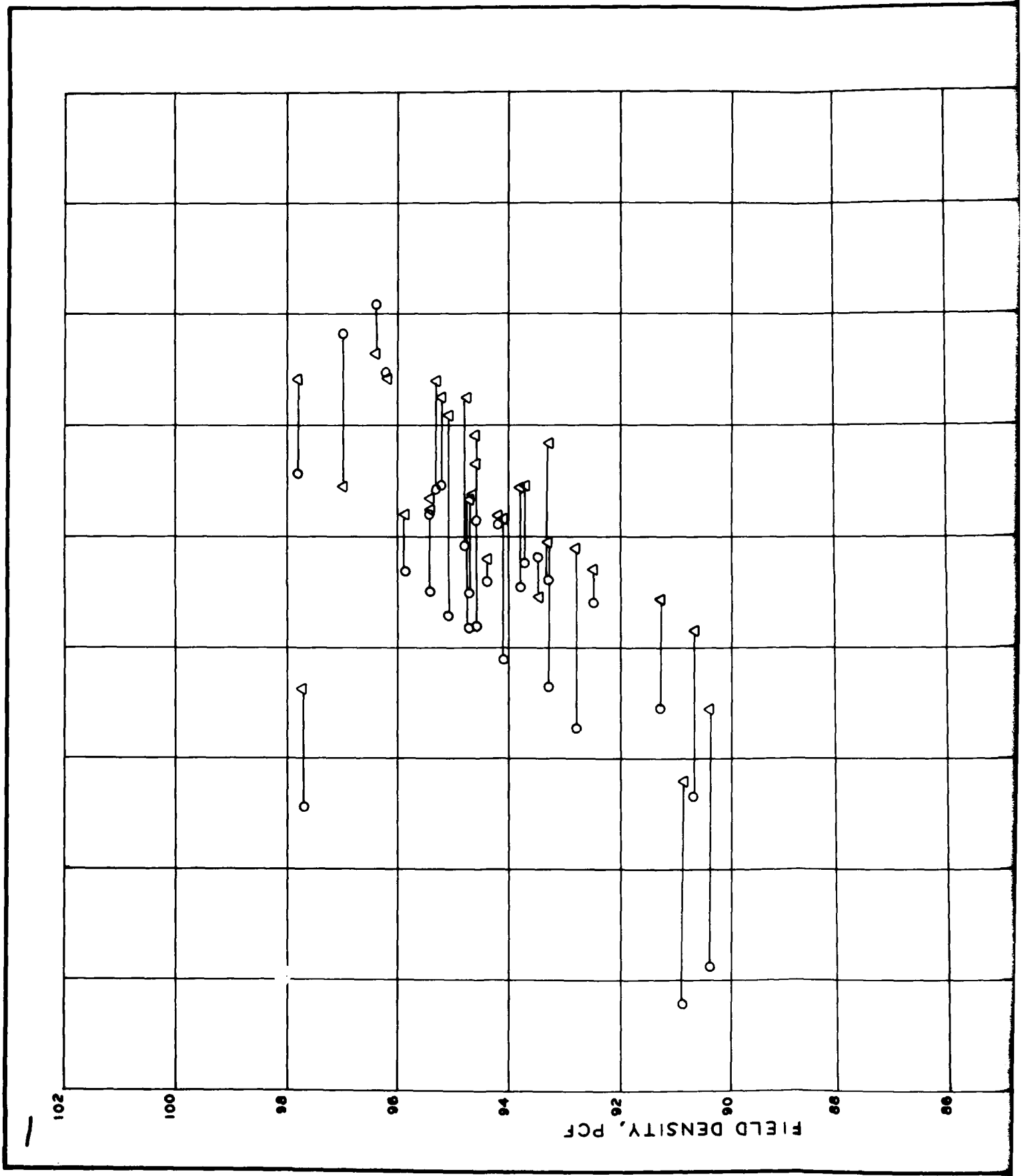


ITEM	RANGE OF VALUES
SPECIFIC GRAVITY	2.68 - 2.72
EFFECTIVE SIZE	0.11 - 0.19

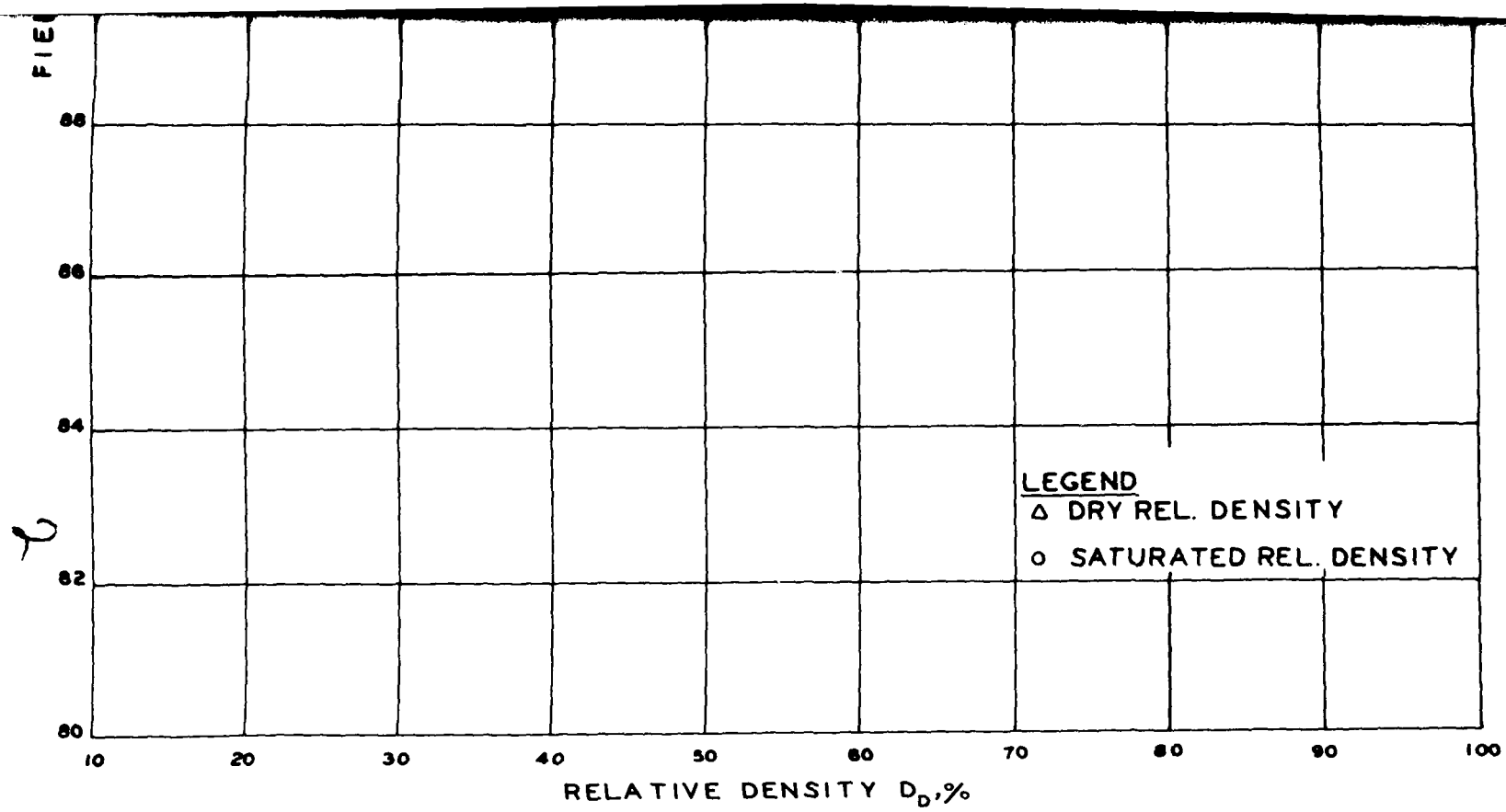
FORT PECK DAM

RELATIVE DENSITY TESTS
EXPERIMENTAL ROLLED HYDRAULIC FILL
(TEST PIT C-3)

U.S. GOVERNMENT PRINTING OFFICE 1981-786



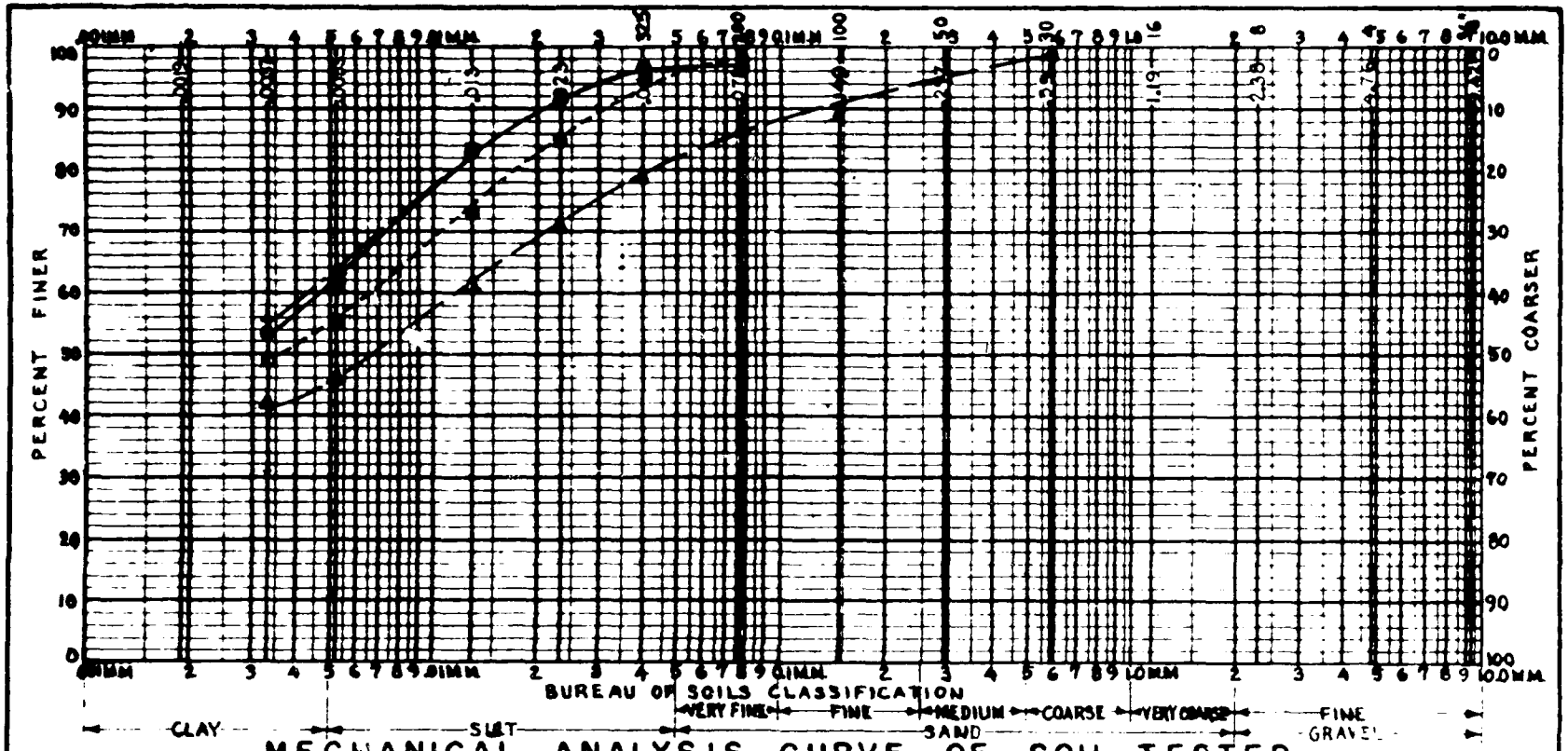
FORT PEC



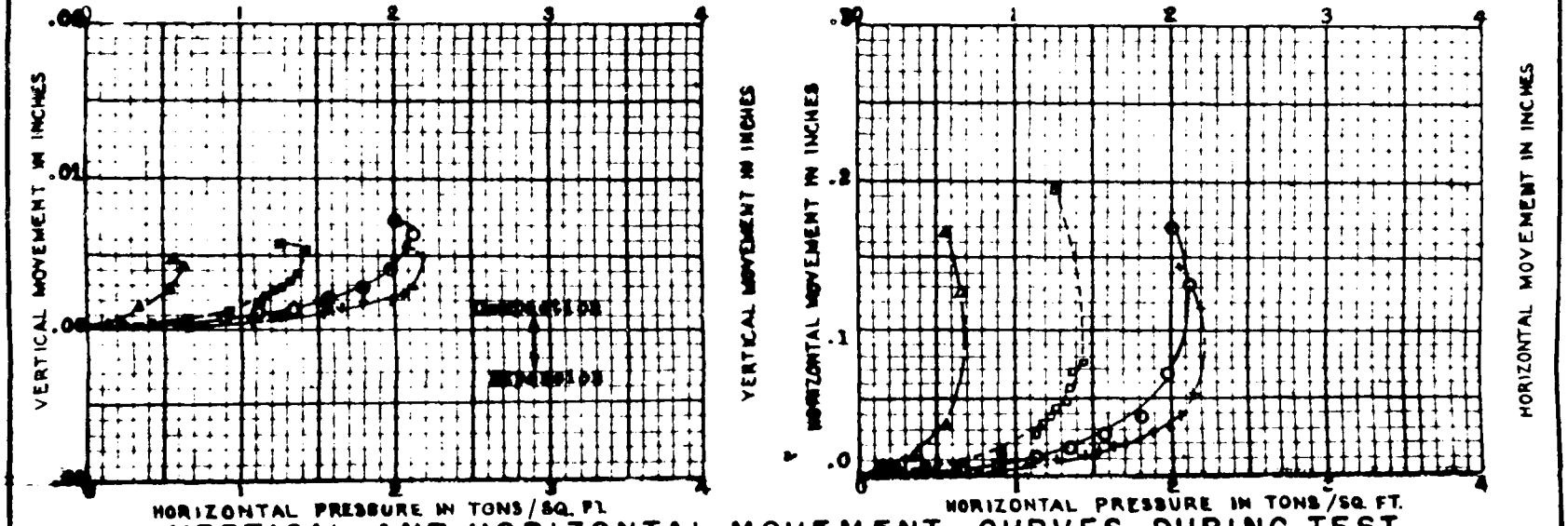
ITEM	RANGE OF VALUES
SPECIFIC GRAVITY	2.67 – 2.71
EFFECTIVE SIZE	0.13 – 0.21

FORT PECK DAM

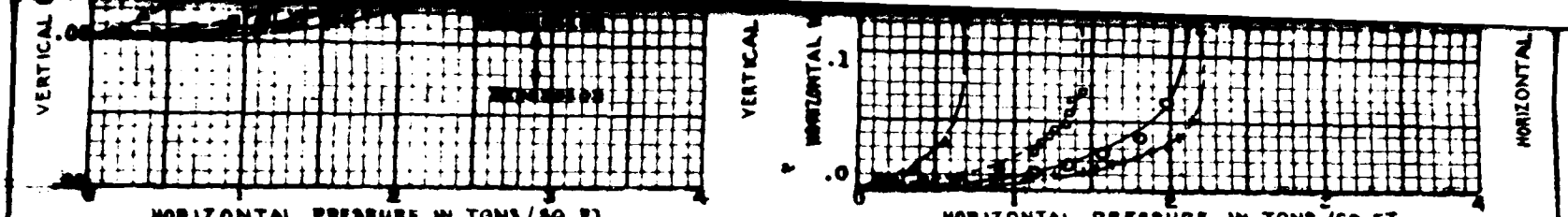
RELATIVE DENSITY TESTS
EXPERIMENTAL ROLLED HYDRAULIC FILL
(TEST PIT C-X)



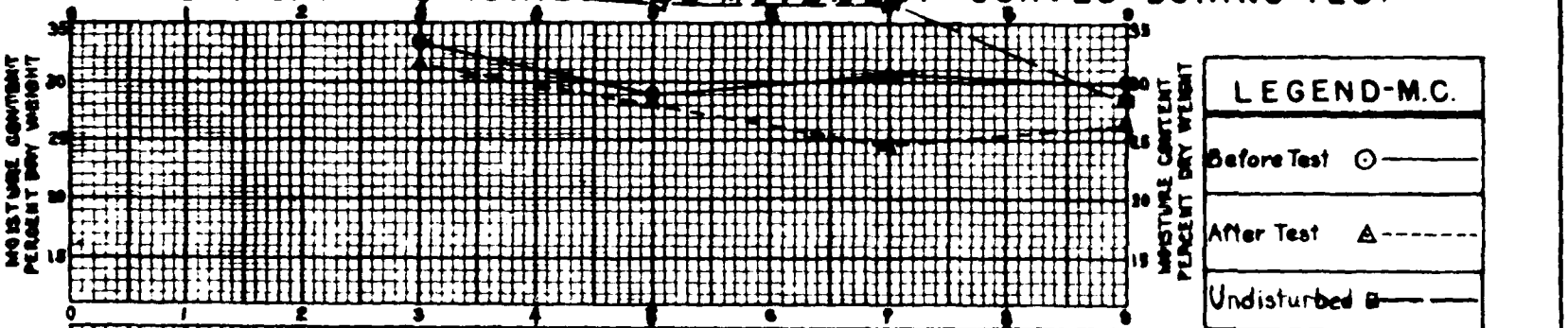
MECHANICAL ANALYSIS CURVE OF SOIL TESTED



VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST

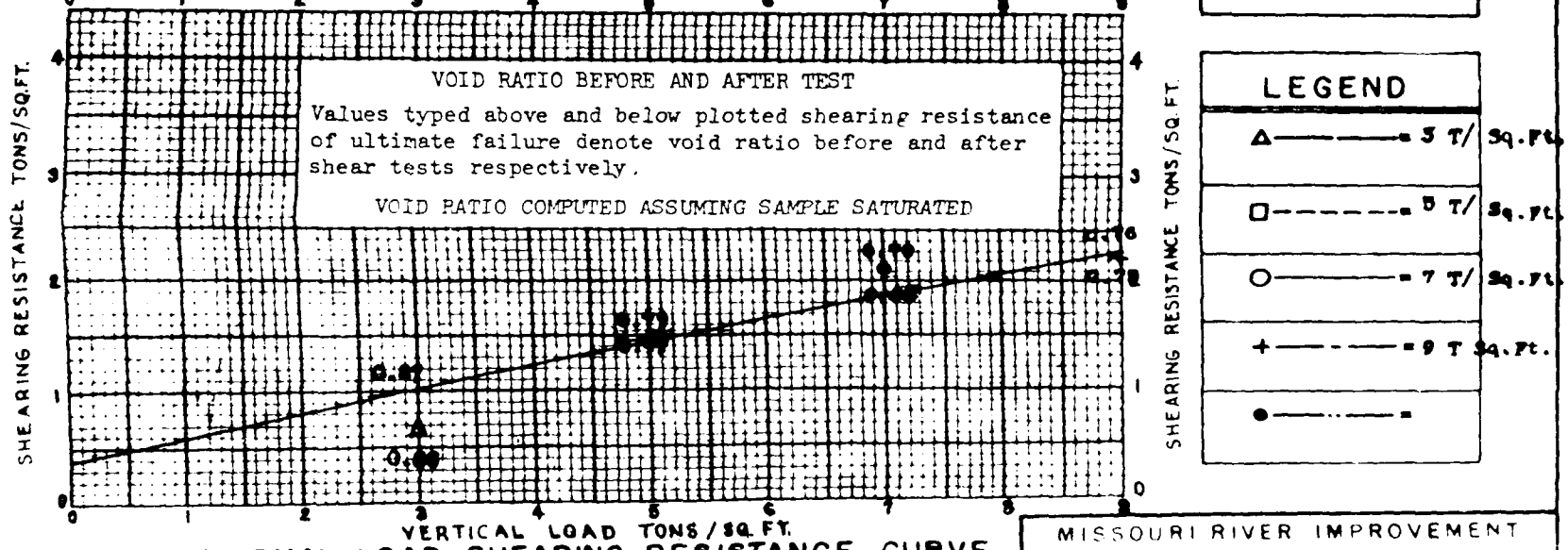


VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



LEGEND-M.C.

- Before Test ⊙——
- After Test △- - - - - -
- Undisturbed ▣— — —



LEGEND

- △——— = 5 T/ Sq.Ft.
- □- - - - - = 5 T/ Sq.Ft.
- ○——— = 7 T/ Sq.Ft.
- +——-——= 9 T Sq.Ft.
- ●——·——=

VERTICAL LOAD TONS/SQ.FT.

NORMAL LOAD-SHEARING RESISTANCE CURVE

$\tan\phi = \frac{\text{Shearing Resistance} - \text{Cohesion (Tons/Sq.Ft.)}}{\text{Vertical Load (Tons/Sq.Ft.)}} = 0.210$

$\phi = 11°50'$

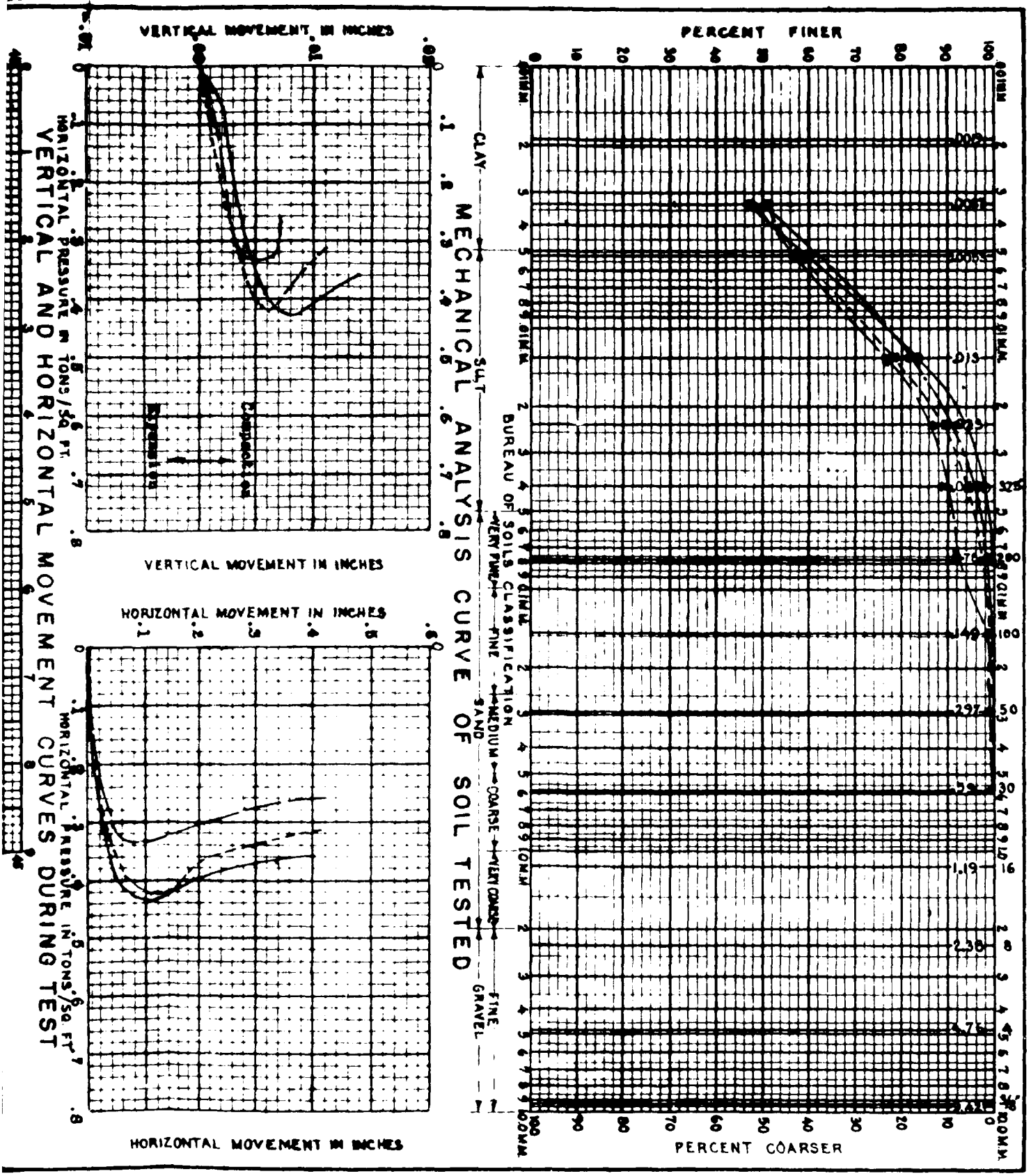
$c = \text{Cohesion} = 0.00$ T/Sq.Ft.

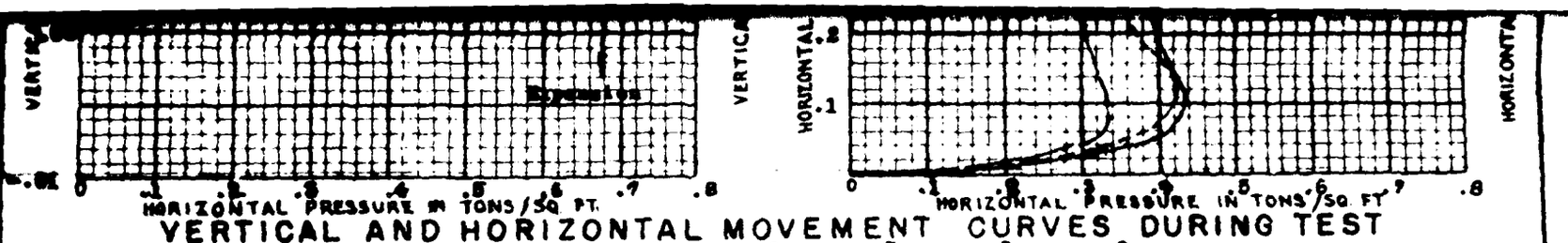
Notes: Undisturbed Samples
Consolidated Shearing Tests
Delta Loading
Elevation 2052.0-2050.8
Depth 46.3-47.5
Cross Sectional Area of Sample -10.00 sq. in.
Initial Thickness 0.75 inch
Sample Immersed in Water During Test
Station SW 27-16 Range 22-25

MISSOURI RIVER IMPROVEMENT
NAVIGATION FLOOD CONTROL & WATER RESOURCES
FORT PECK DAM
SLIDE INVESTIGATION
SHEAR TESTS SURFACE CLAY
HOLE C-11 SAMPLE # 3'
ENGINEER OFFICE, FORT PECK, MONT.

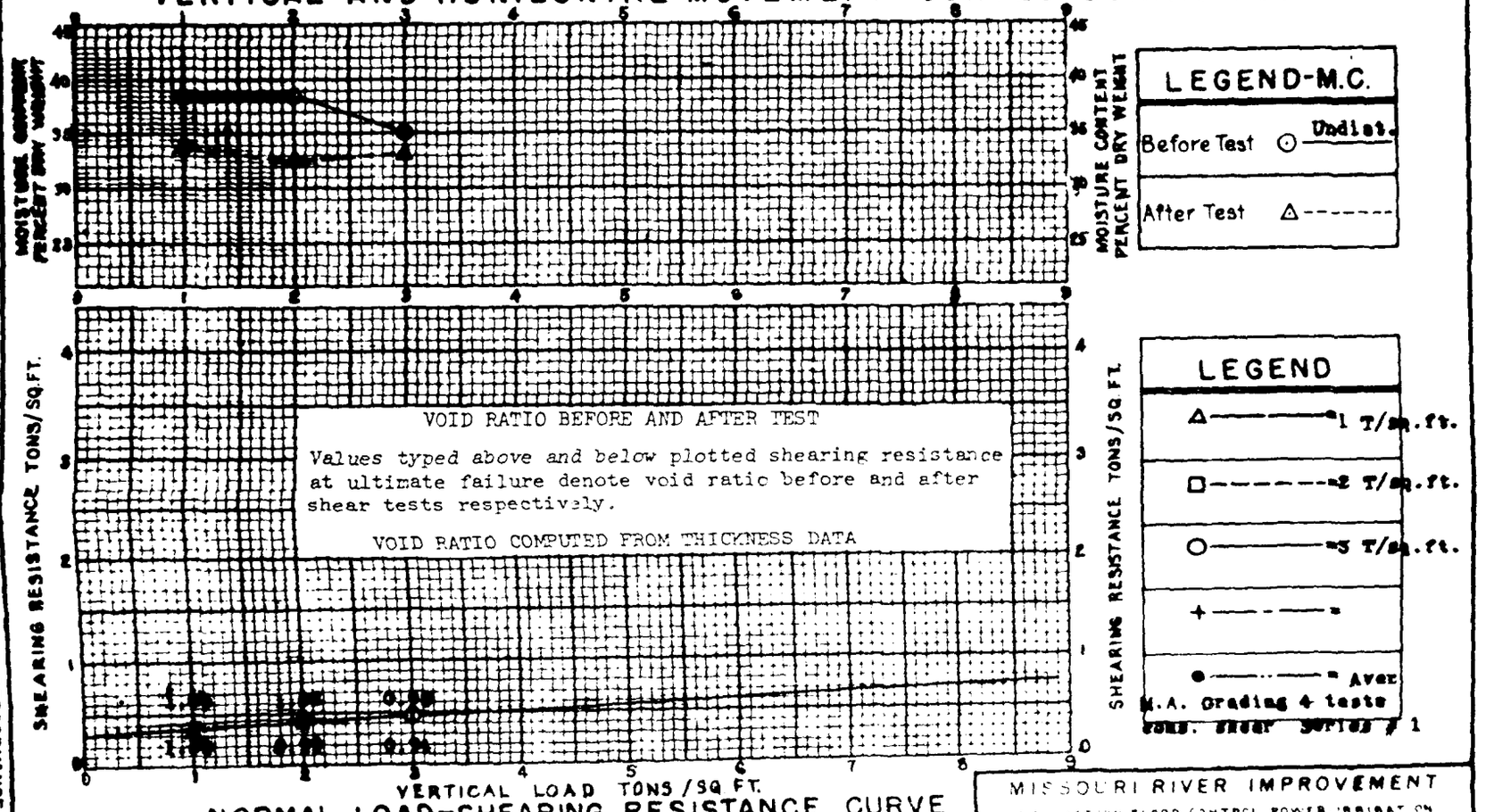
Submitted	Approved recommended	Approved
	Major Div. Engineer	Chief Engineer

Drawn by	Traced by	Checked by	Transmitted with report dated	Sheet No
J L S	B B C	D B D		


VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST
VERTICAL MOVEMENT IN INCHES
Expansion
Compression
VERTICAL MOVEMENT IN INCHES
HORIZONTAL PRESSURE IN TONS/SQ. FT.
HORIZONTAL MOVEMENT IN INCHES
HORIZONTAL MOVEMENT IN INCHES
MECHANICAL ANALYSIS CURVE OF SOIL TESTED
BUREAU OF SOILS CLASSIFICATION
CLAY
SILT
FINE
MEDIUM
COARSE
FINE
SAND
GRAVEL
PERCENT FINER
PERCENT COARSER
.005
.013
.025
.074
.149
.297
.59
1.19
2.38
4.76



VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



NORMAL LOAD-SHEARING RESISTANCE CURVE

$\tan\phi = \frac{\text{Shearing Resistance} - \text{Cohesion (Tons/Sq Ft)}}{\text{Vertical Load (Tons/Sq Ft)}} = 0.051$

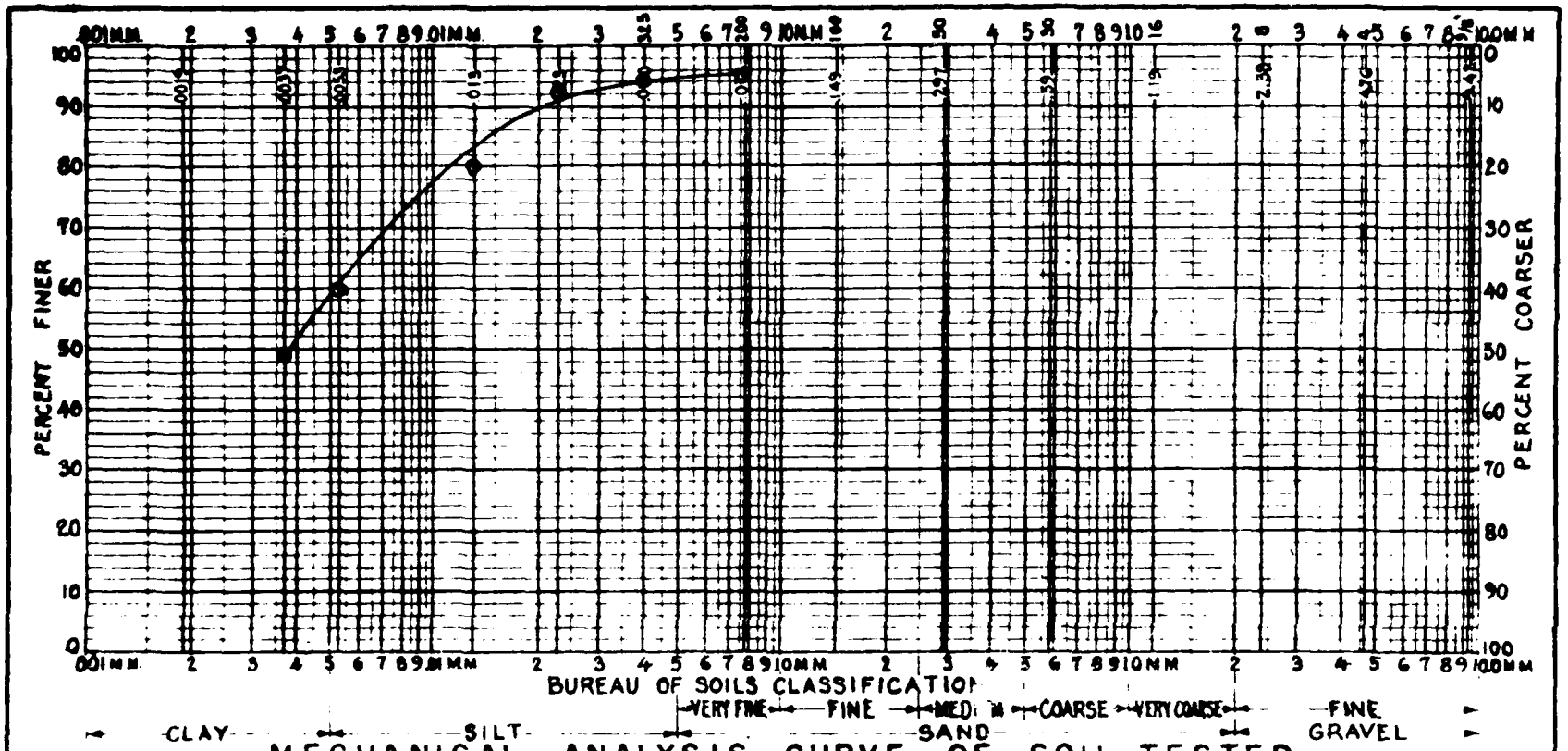
$\phi = 2^{\circ}55'$

c = Cohesion = 0.30 T/sq.ft.

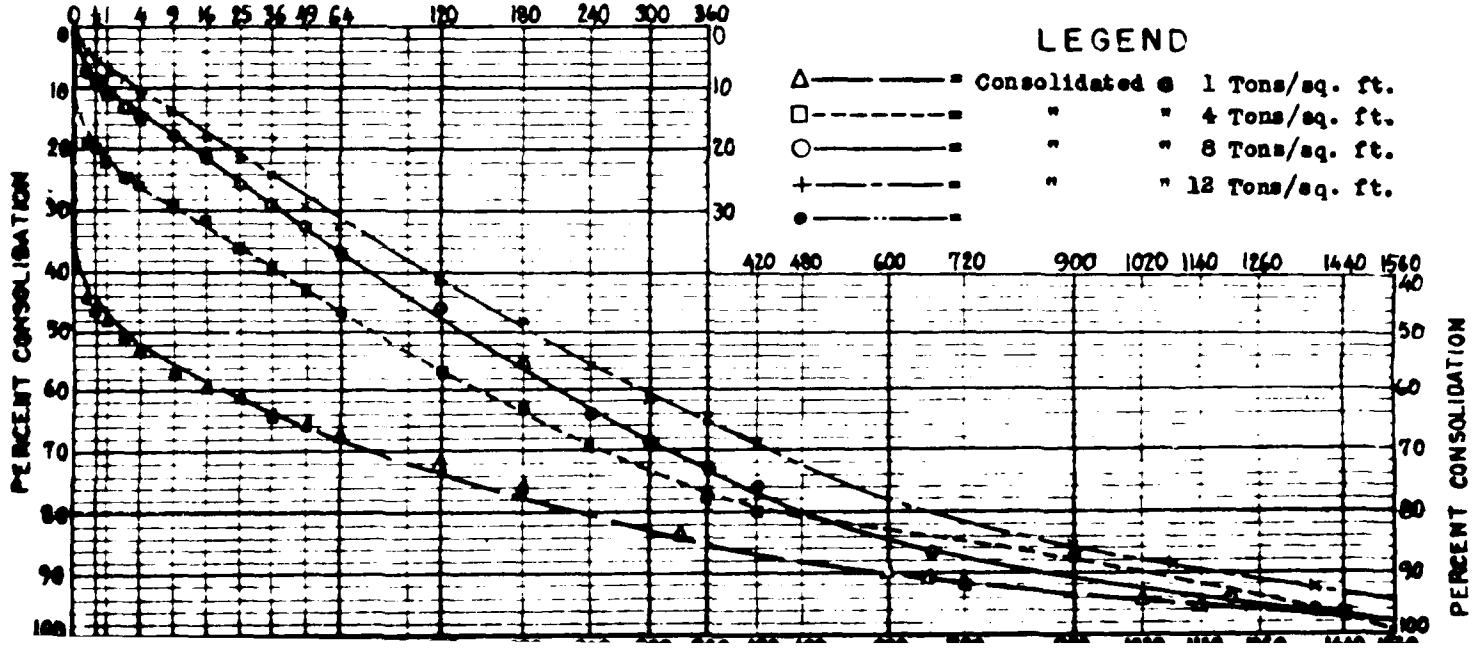
Notes: Undisturbed Sample
Quick Shear Tests
Constant Strain Loading
Elevation 2053.1-2052.5
Depth- 48.2-48.8'
Cross sectional area of sample 10.00 sq. in.
Initial [illegible]
Sample [illegible]
Ratio [illegible]
Maximum [illegible] at 20 [illegible] per 0.01" min.

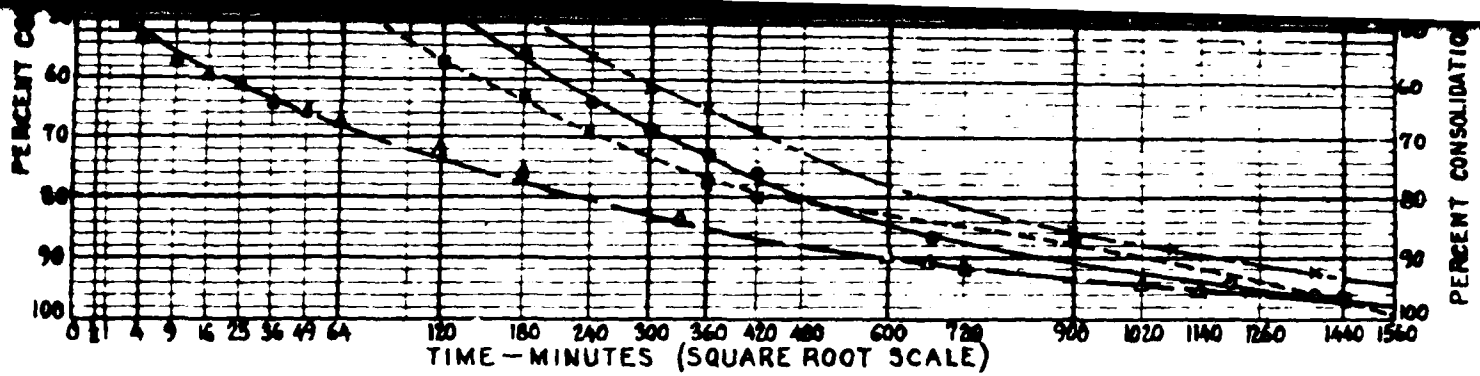
MISSOURI RIVER IMPROVEMENT
NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION
FORT PECK DAM
SLIDE INVESTIGATION
Quick Shear Tests-Series # 3
SURFACE CLAY-HOLE C-11 Sample # 2
[illegible] FORT PECK, MONT. 2-4-39

Drawn by	Traced by	Checked by	Approved recommended	Approved	Transmitted with report dated	File No.
J L B	W B C	J L P				

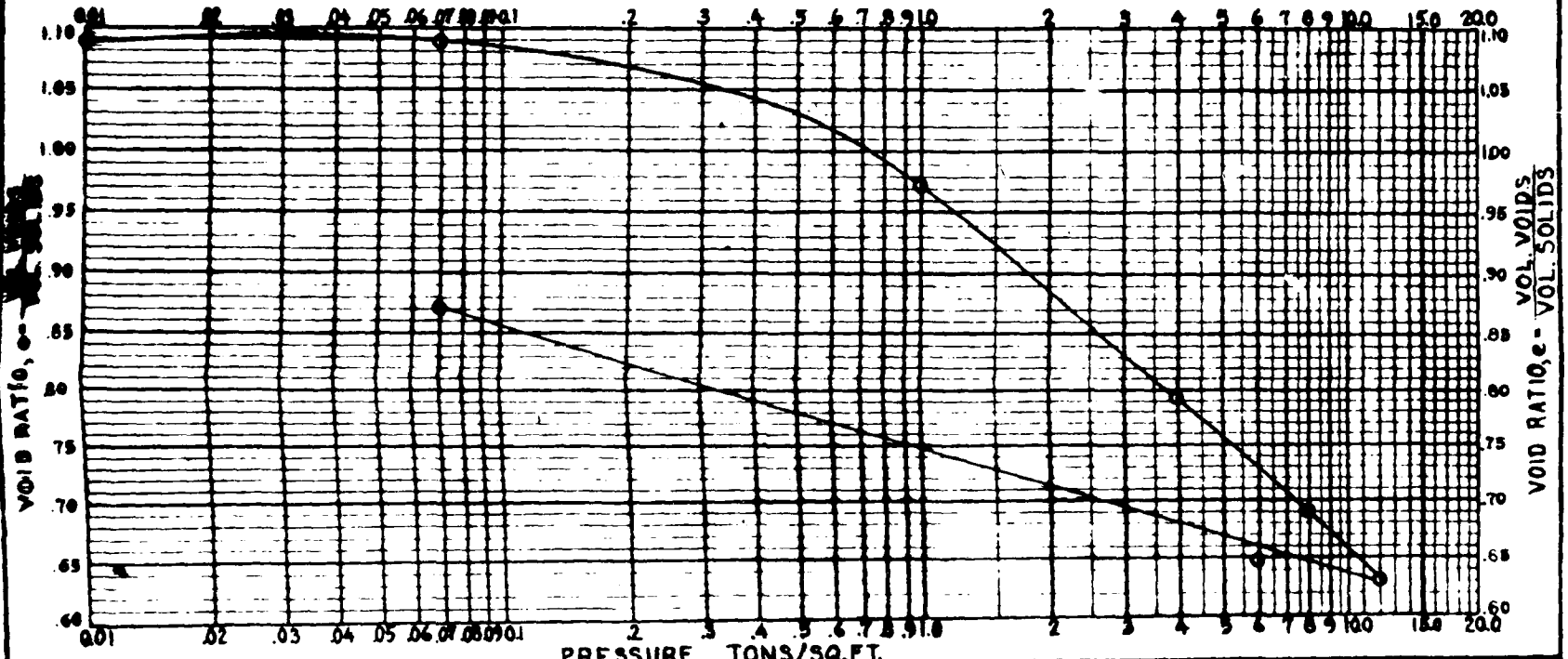


MECHANICAL ANALYSIS CURVE OF SOIL TESTED





TIME—PERCENT CONSOLIDATION CURVES



PRESSURE-VOID RATIO CURVE

Estimated Previous Consolidation - Tons/Sq Ft.

VERTICAL LOAD TONS/SQ FT.	COMPACTION PERCENT*
0.00	0.00
0.07	0.00
1.00	5.58
4.00	14.10
8.00	19.11
12.00	24.75
8.00	21.00
0.07	10.17

Undisturbed Sample Immersed in Water during test
Station 27 + 16, Range 22 + 22-U
Initial Thickness 1.00 inch
Cross Sectional Area 24.80 sq. in.
Elevation - 2051.8 - Depth 46.5'

* Total compaction in percent of original height of sample.

MISSOURI RIVER IMPROVEMENT
NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION

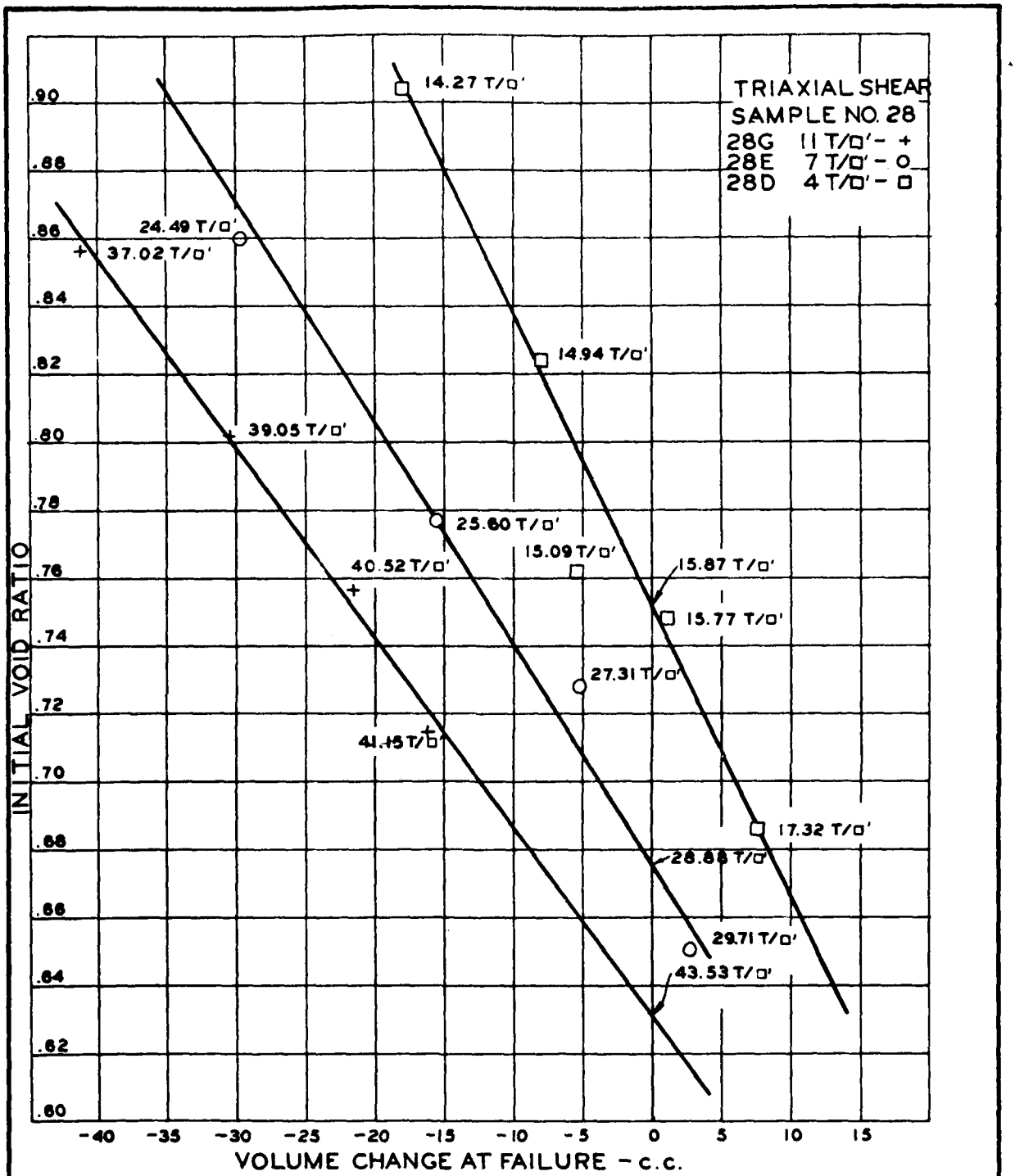
FORT PECK DAM

SLIDE INVESTIGATION
CONSOLIDATION TEST SURFACE CLAY
HOLE C-11, SAMPLE NO. 3
U.S. ENGINEER OFFICE, FORT PECK, MONT. 1-13-39

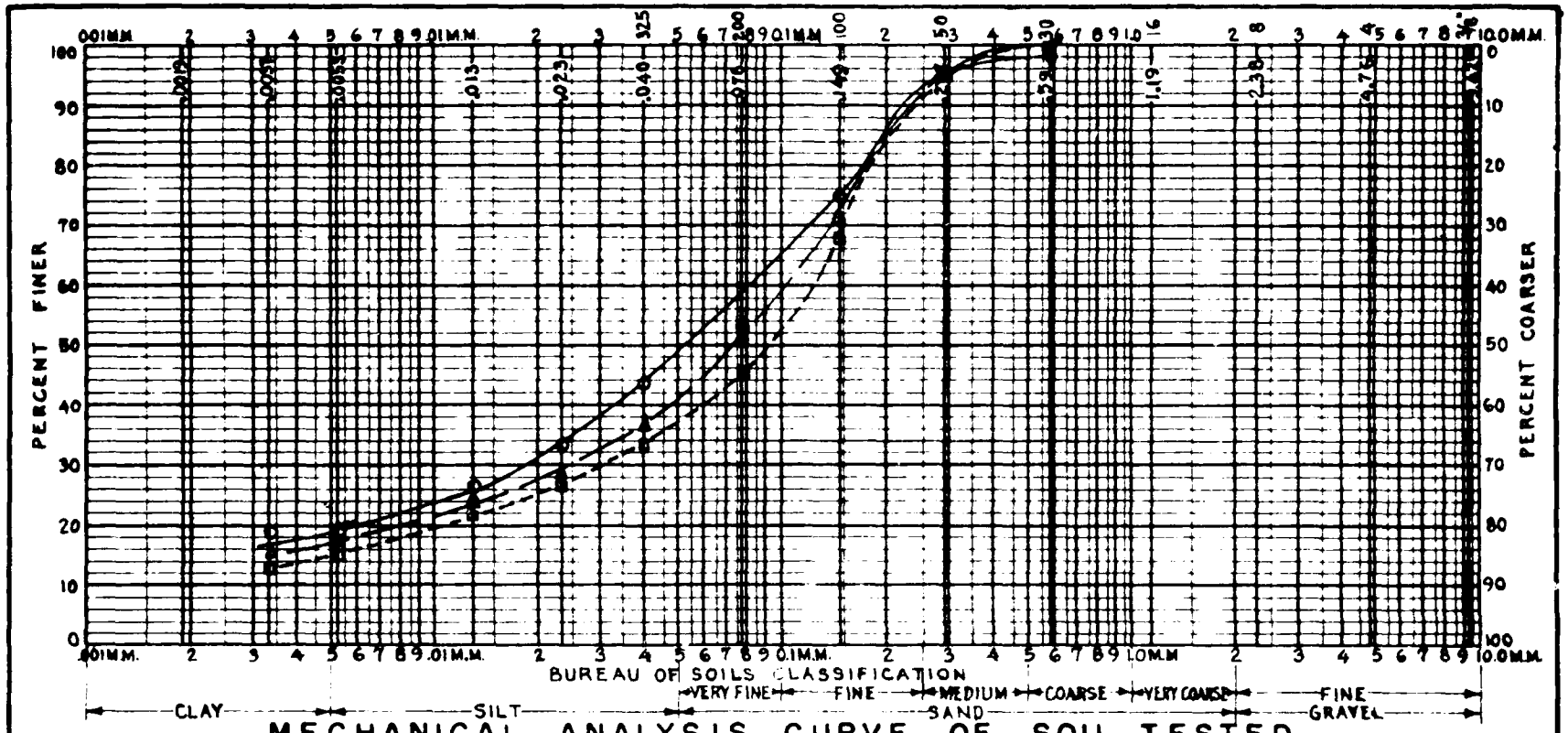
Submitted	Approval Recommended	Approved
	Water Control Engineer	Lt. Col. Corps of Engineers

Drawn by	Traced by	Checked by	Transmitted with report dated	File No.
DWS	EBC	WA		

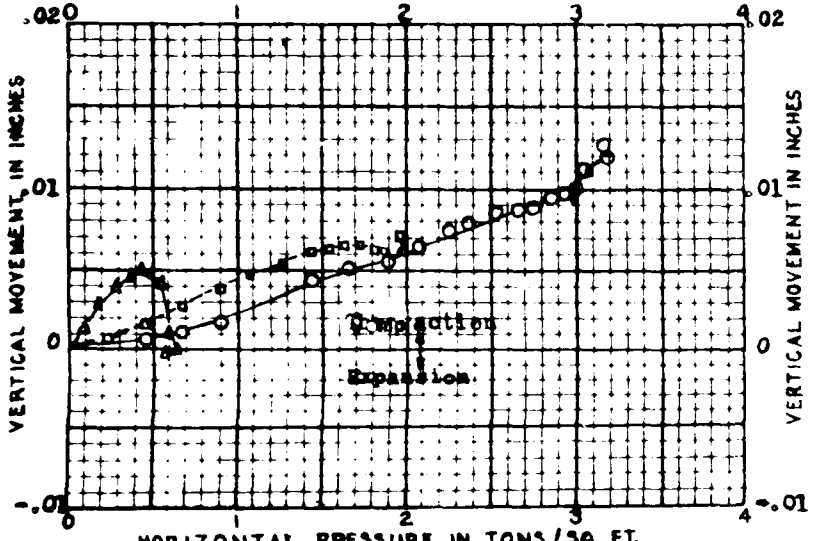
SHEET 22

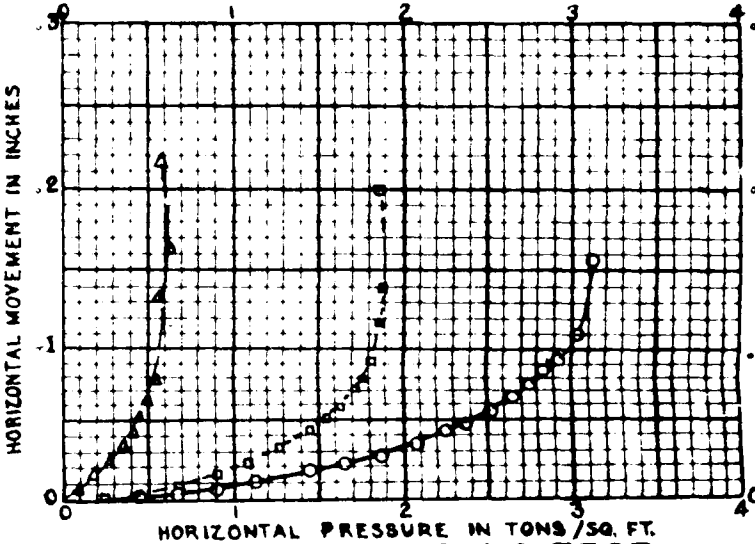


FORT PECK DAM
TYPICAL CRITICAL VOID RATIO TESTS
ON FOUNDATION SANDS

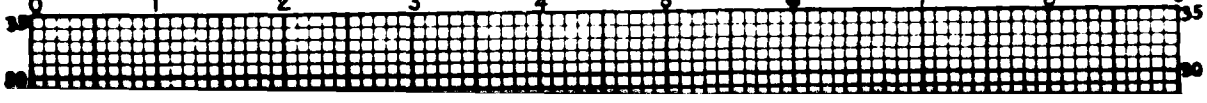


MECHANICAL ANALYSIS CURVE OF SOIL TESTED

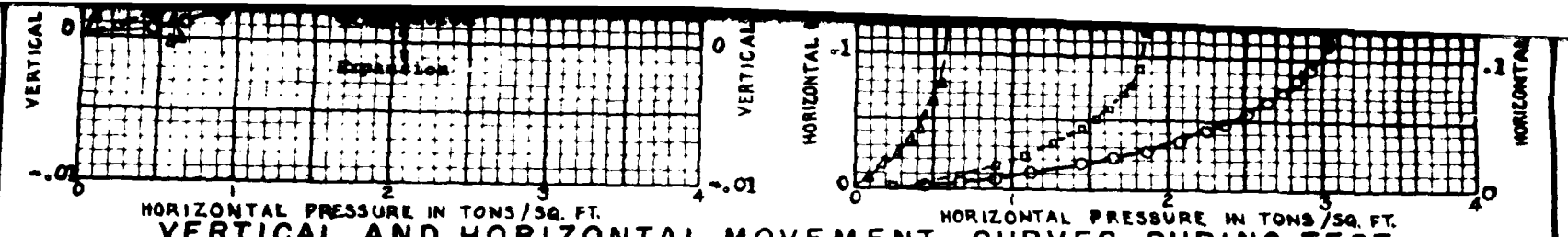




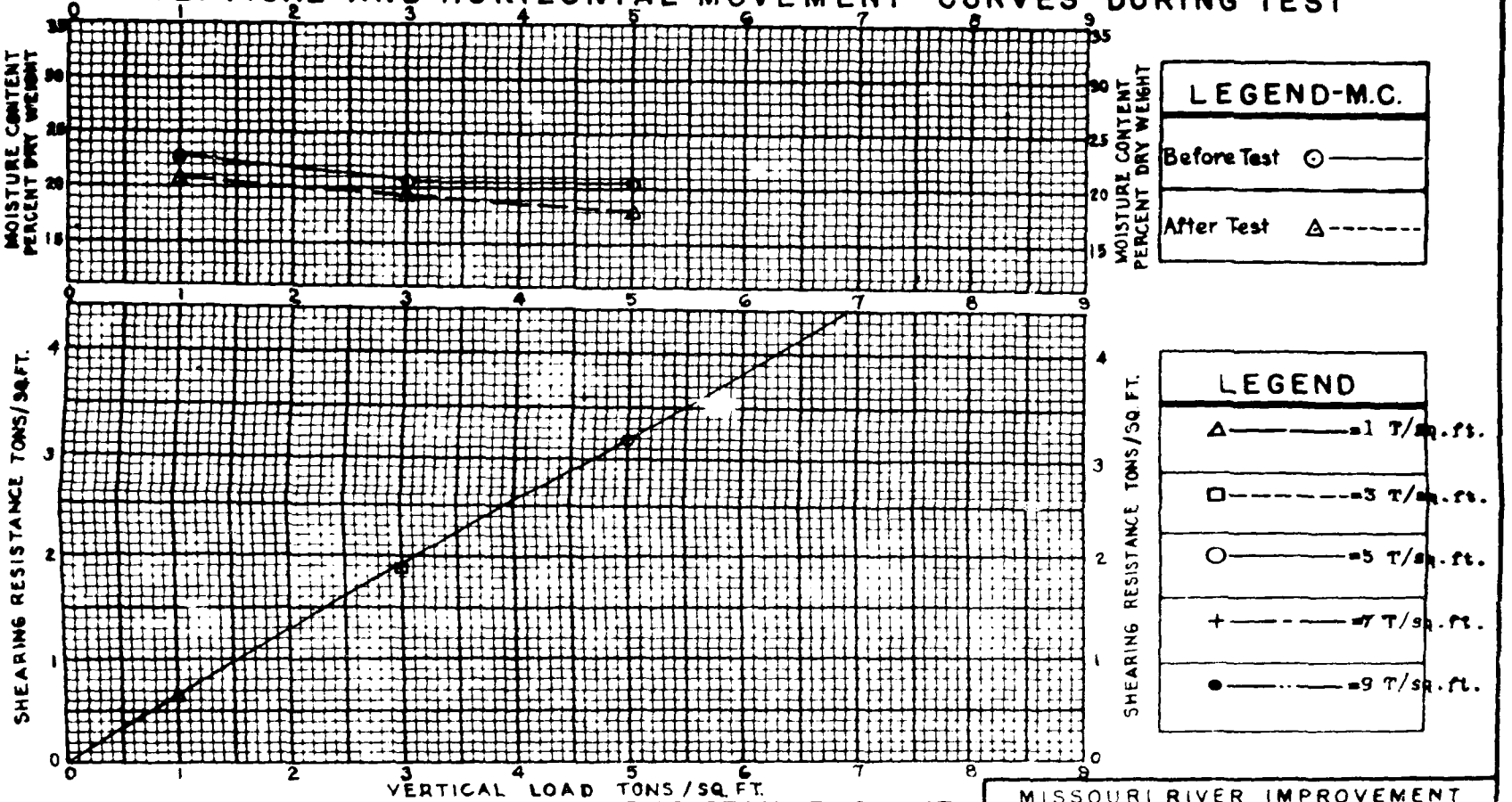
VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



LEGEND-M.C.



VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



NORMAL LOAD-SHEARING RESISTANCE CURVE

$\tan\phi = \frac{\text{Shearing Resistance} - \text{Cohesion (Tons/Sq Ft)}}{\text{Vertical Load (Tons/Sq Ft)}} = 0.633$

$\phi = 32^\circ 20'$

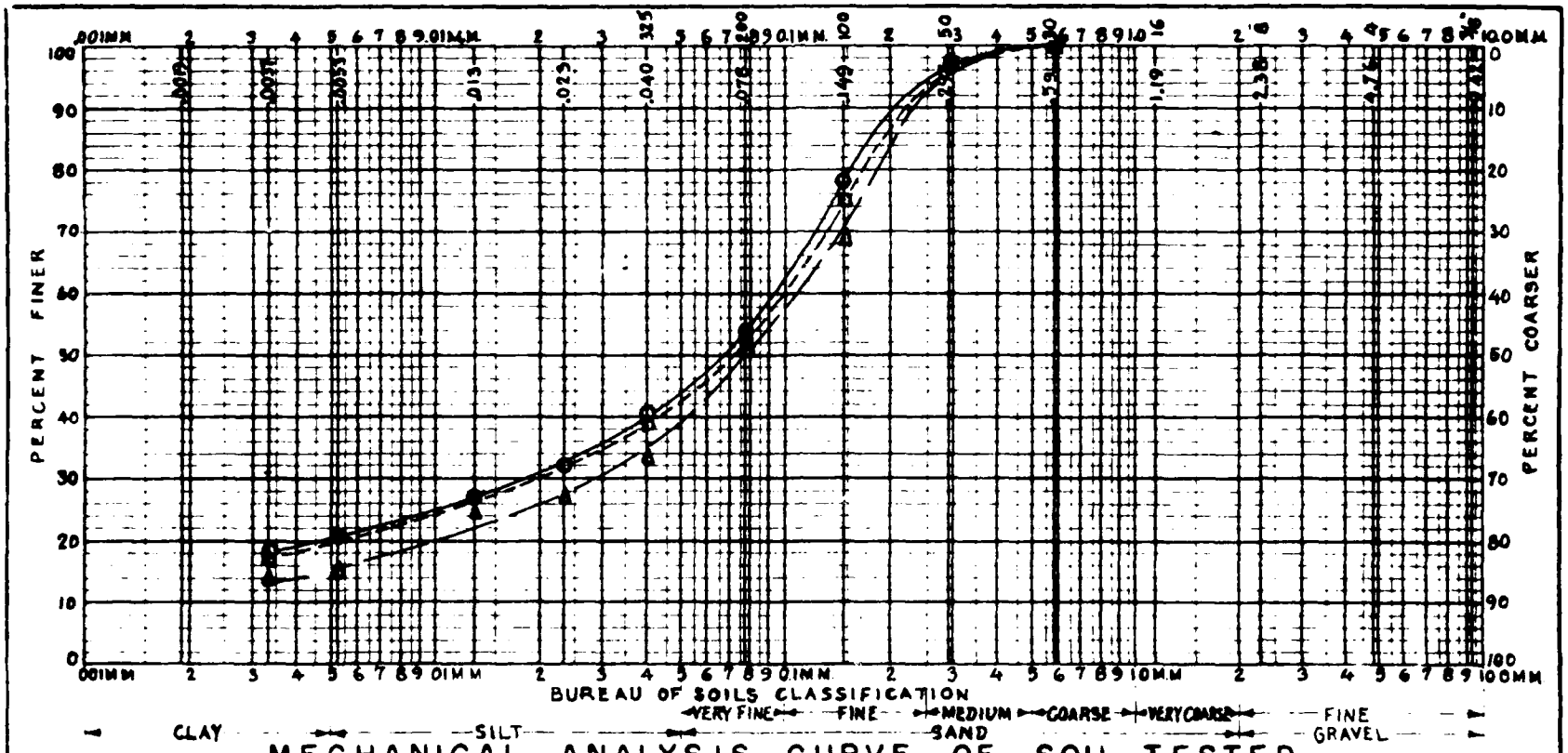
$c = \text{Cohesion} = 0.0$ T/sq.ft.

Notes: Undisturbed Sample
Consolidated Shear Tests
Increment Loading
Elevation 2230.1 - 2231.0
Depth 14.0 - 14.7
Cross Sectional Area of Sample 10.[illegible] sq. in.
Initial Thickness 0.7[illegible] inch
Sample immersed in water during test
Stroke [illegible] - Range [illegible] / 352

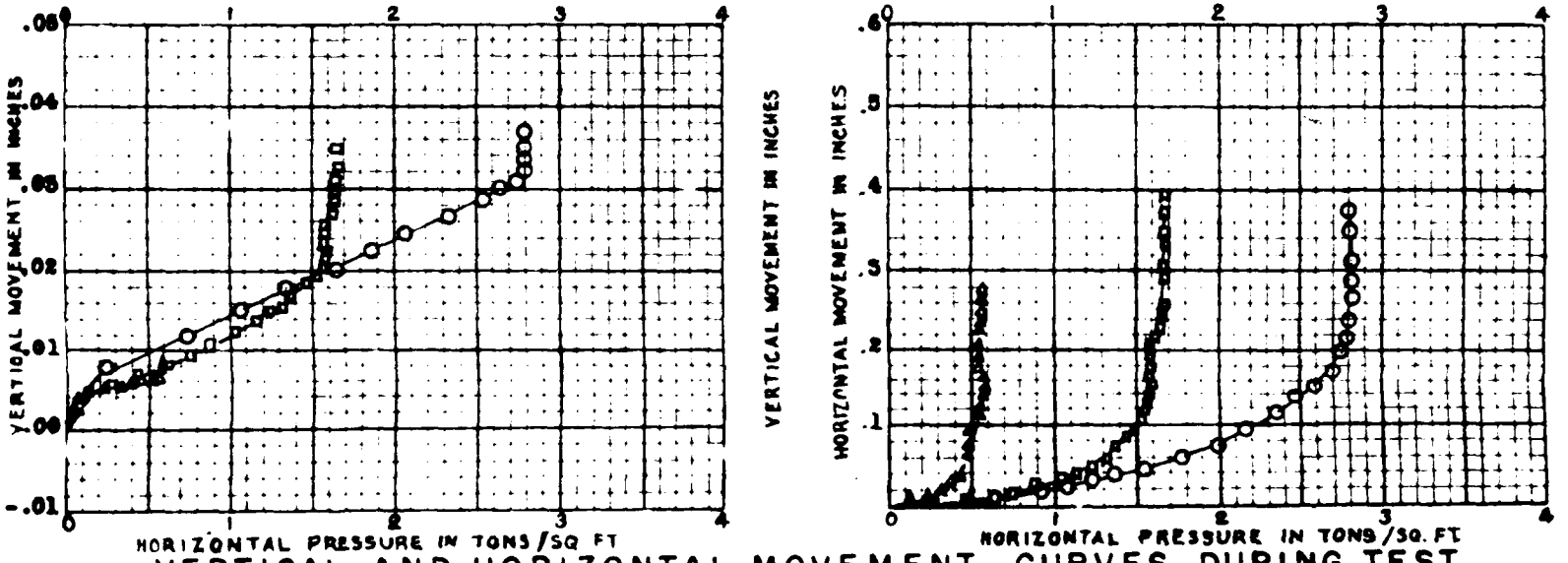
MISSOURI RIVER IMPROVEMENT
NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION
FORT PECK DAM
SLIDE INVESTIGATION
SHEAR TESTS ON CORE MATERIAL
HOLE C-7 - SAMPLE #3
U.S. ENGINEER OFFICE, FORT PECK, MONT. 1-3-39

Submitted	Approval Recommended	Approved
	Major Corps of Engineers	Major Corps of Engineers

Drawn by	Traced by	Checked by	Transmitted with report dated	File No.
JLB	BSC	JC		

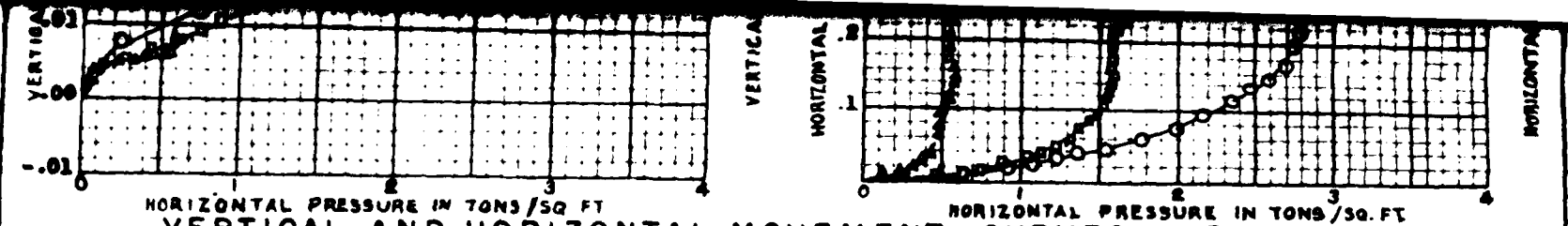


MECHANICAL ANALYSIS CURVE OF SOIL TESTED

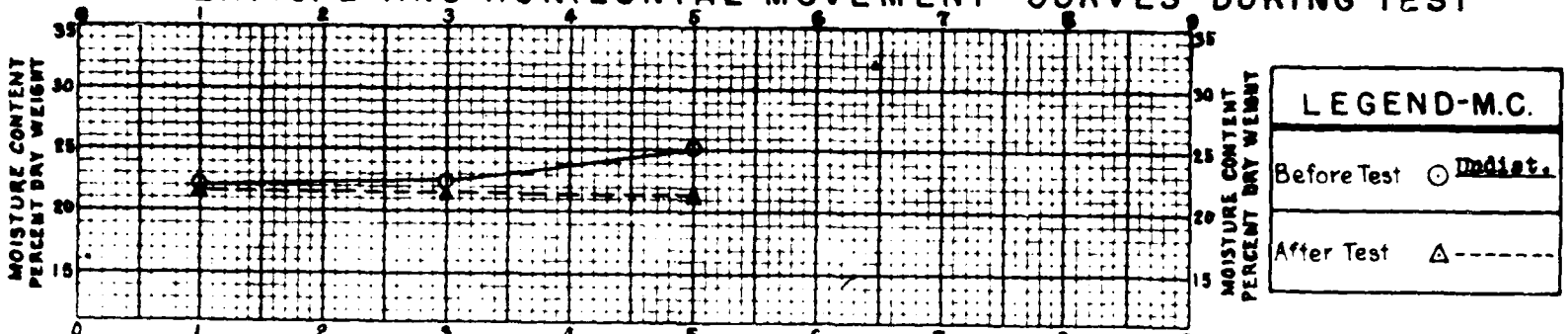


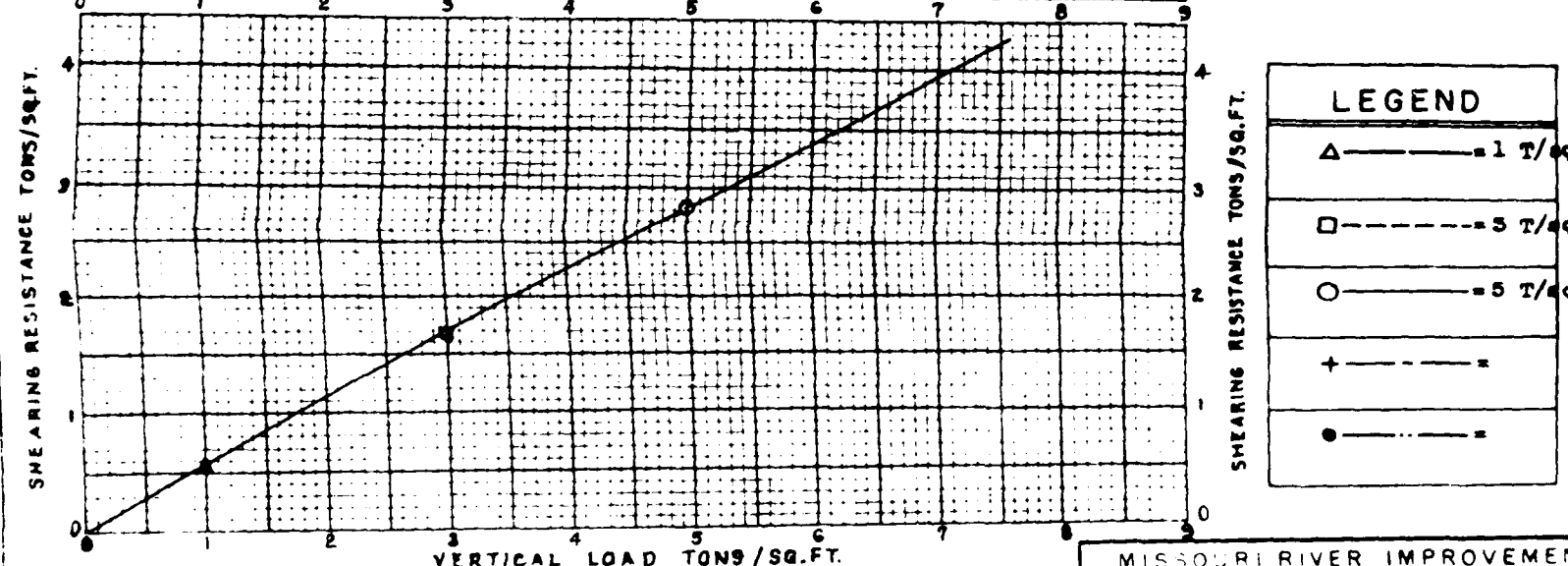
VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST

LEGEND-M.C.



VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST





NORMAL LOAD-SHEARING RESISTANCE CURVE

$\tan\phi = \frac{\text{Shearing Resistance}}{\text{Vertical Load (Tons/Sq Ft)}}$

$\tan\phi = 0.564$

$\phi = 29^\circ\ 25'$

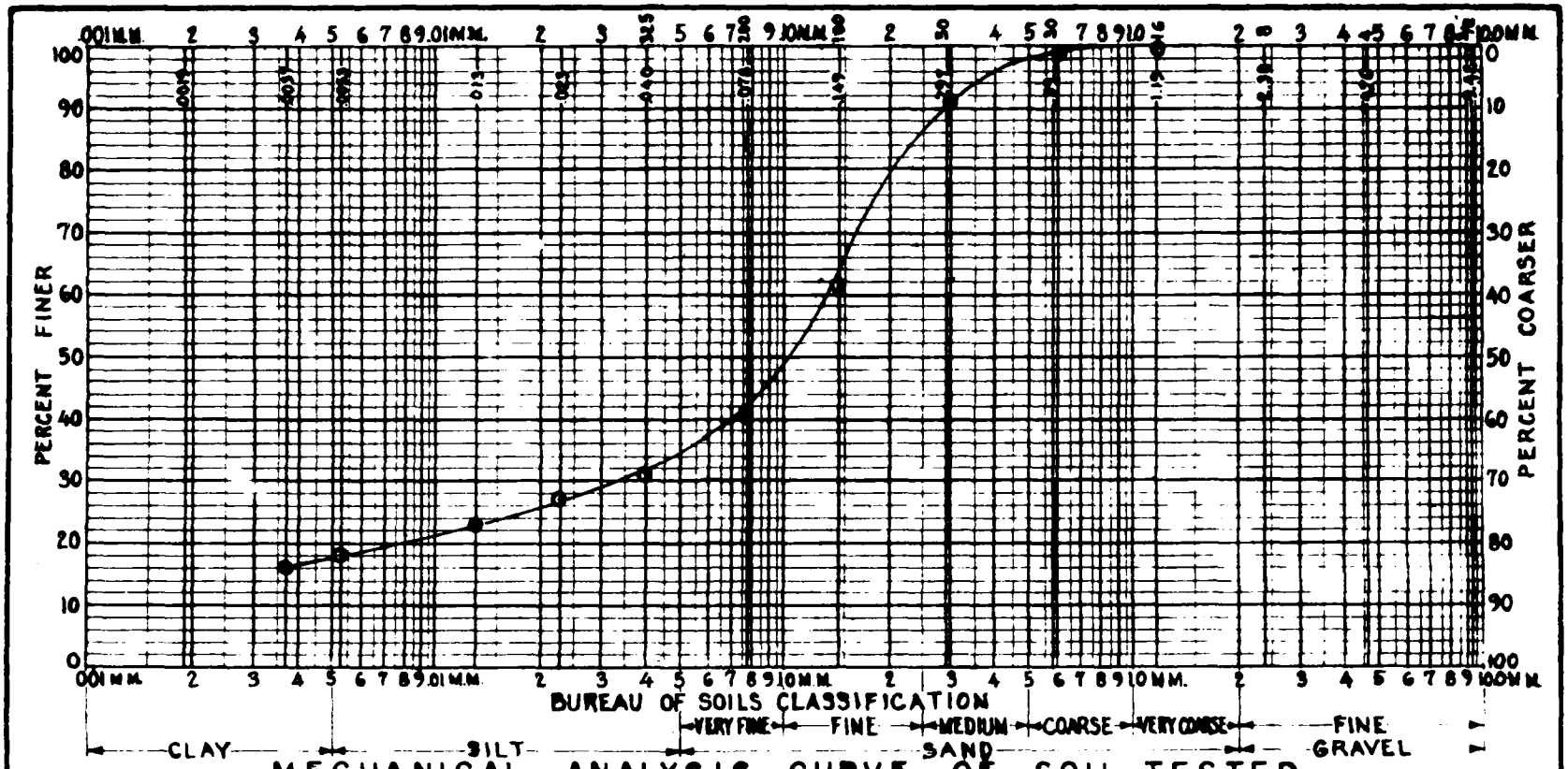
c = Cohesion = 0.0 T/sq.ft.

Notes:
Undisturbed Sample
Quick Shear Tests
Constant Strain Loading
Maximum rate of horizontal movement 0.021"/min
Elevation 2226.8 - 2226.3
Depth 20.9 - 21.4
Cross Sectional Area of Sample 16.00 sq. in.
Initial Thickness 0.75 inch.
Sample Immersed in Water during test
Station 60; Range C ⅄ 35-D

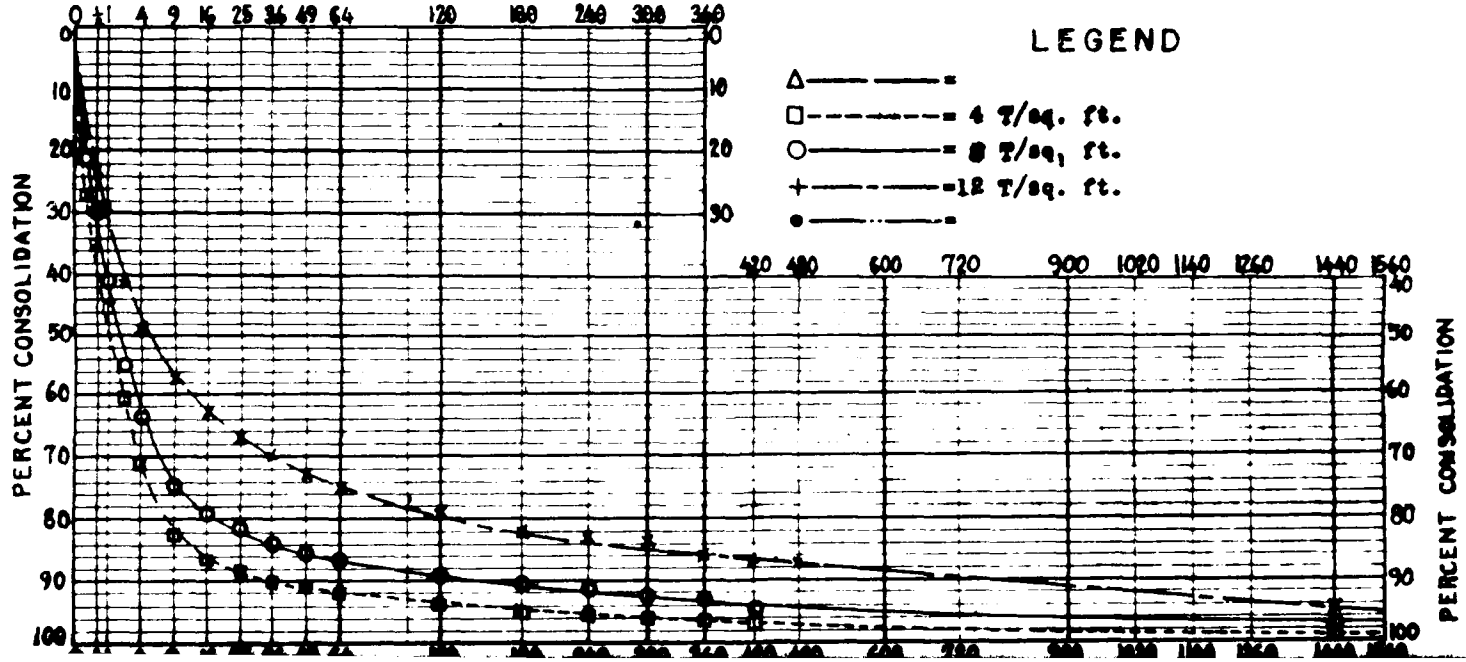
MISSOURI RIVER IMPROVEMENT
NAVIGATION FLOOD CONTROL, POWER, IRRIGATION
FORT PECK DAM
SLIDE INVESTIGATION
QUICK SHEAR TESTS - CORE MATERIAL
HOLE C-7, SAMPLE #5, SERIES #1
ENG WKS OFF CE, FORT PECK MONT

JLB	EBC			

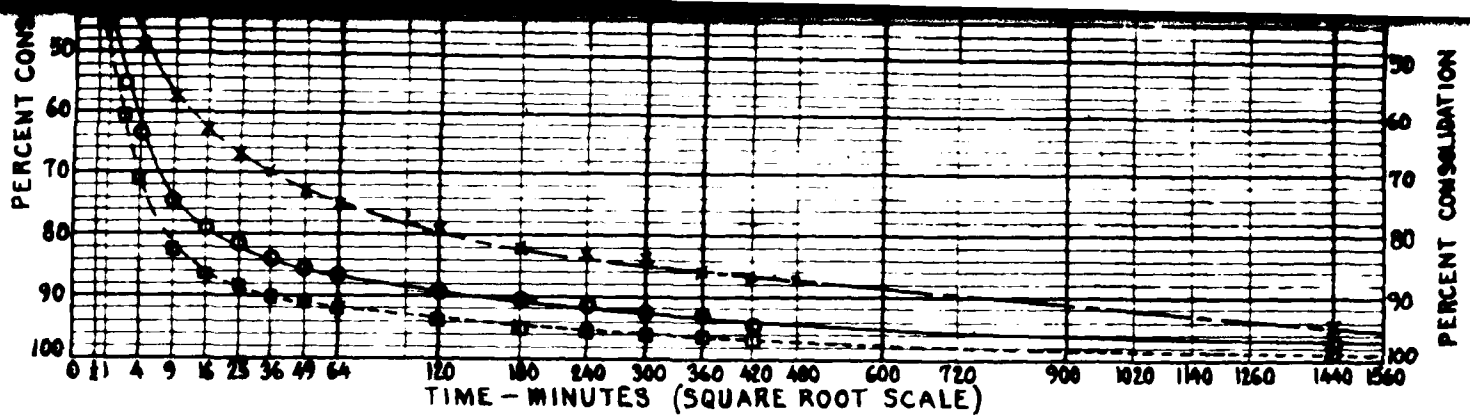
SHEET 25



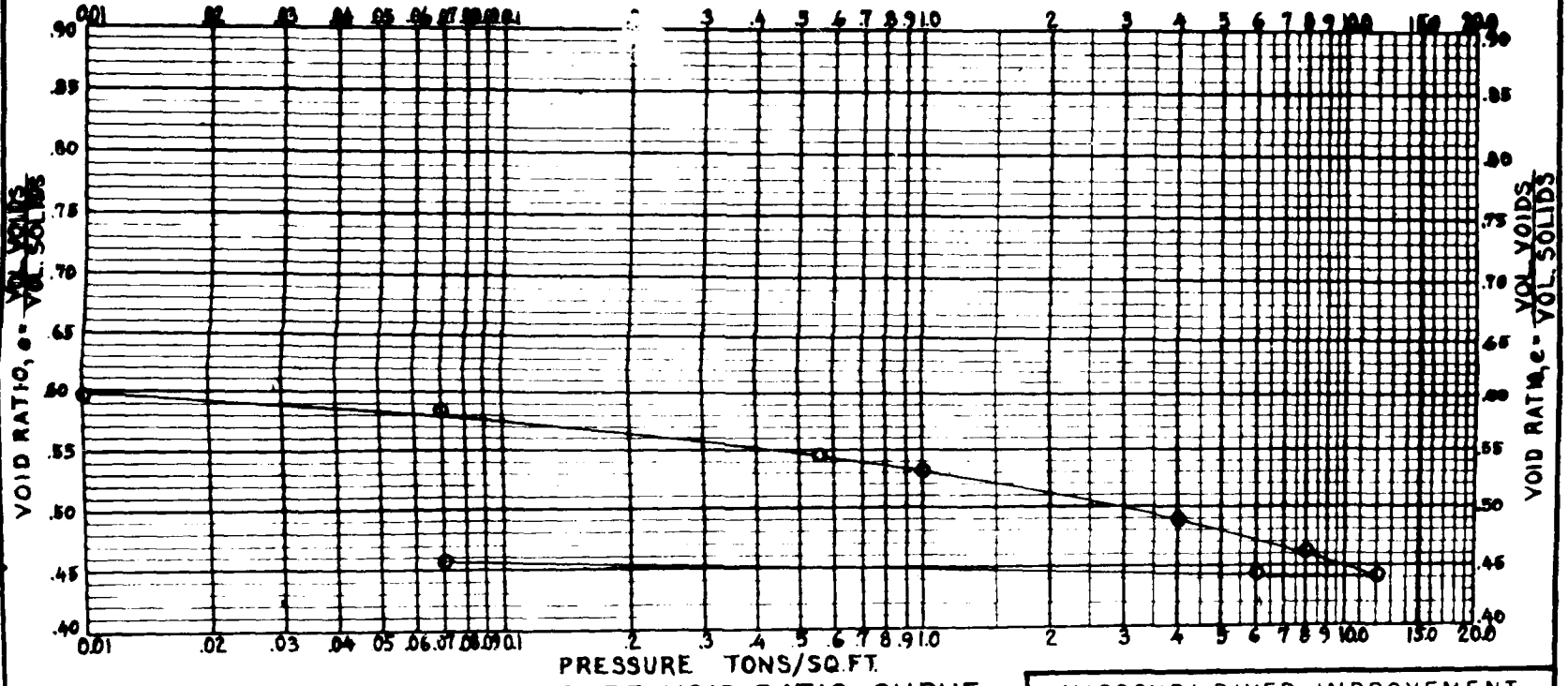
MECHANICAL ANALYSIS CURVE OF SOIL TESTED



FORT



TIME–PERCENT CONSOLIDATION CURVES



PRESSURE-VOID RATIO CURVE

Estimated Previous Consolidation = Tons/Sq.Ft.

VERTICAL LOAD TONS/SQ.FT.	COMPACTION PERCENT*
0.	0.
0.07	.58
0.56	3.34
1.00	4.00
4.00	6.71
8.00	8.28
12.00	9.70
6.00	9.60
0.07	8.65

Undisturbed sample
Immersed in water during test
Station 60 + 00 Range 0 + 35D
Depth 13.5 Elev. 2234.2
Initial Thickness 2.50"
Cross Sectional Area of sample 24.8 sq. in.
Natural Moisture Content 23.0%

* Total compaction in percent of original height of sample.

MISSOURI RIVER IMPROVEMENT
NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION

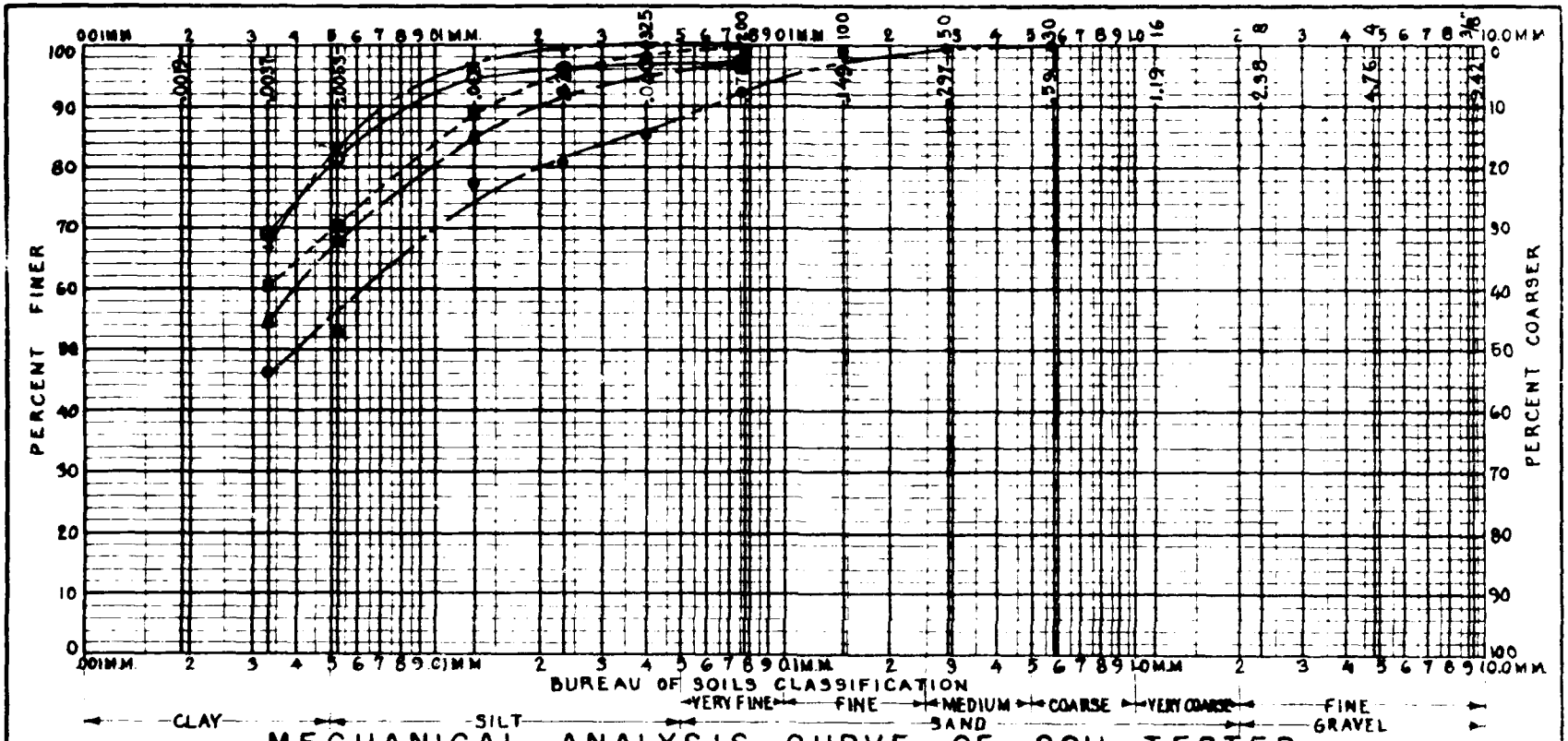
FORT PECK DAM

SLIDE INVESTIGATION
CONSOLIDATION TESTS ON CORE MATERIAL
HOLE C-7 - SAMPLE #2
U.S. ENGINEER OFFICE, FORT PECK, MONT. 12-12-38

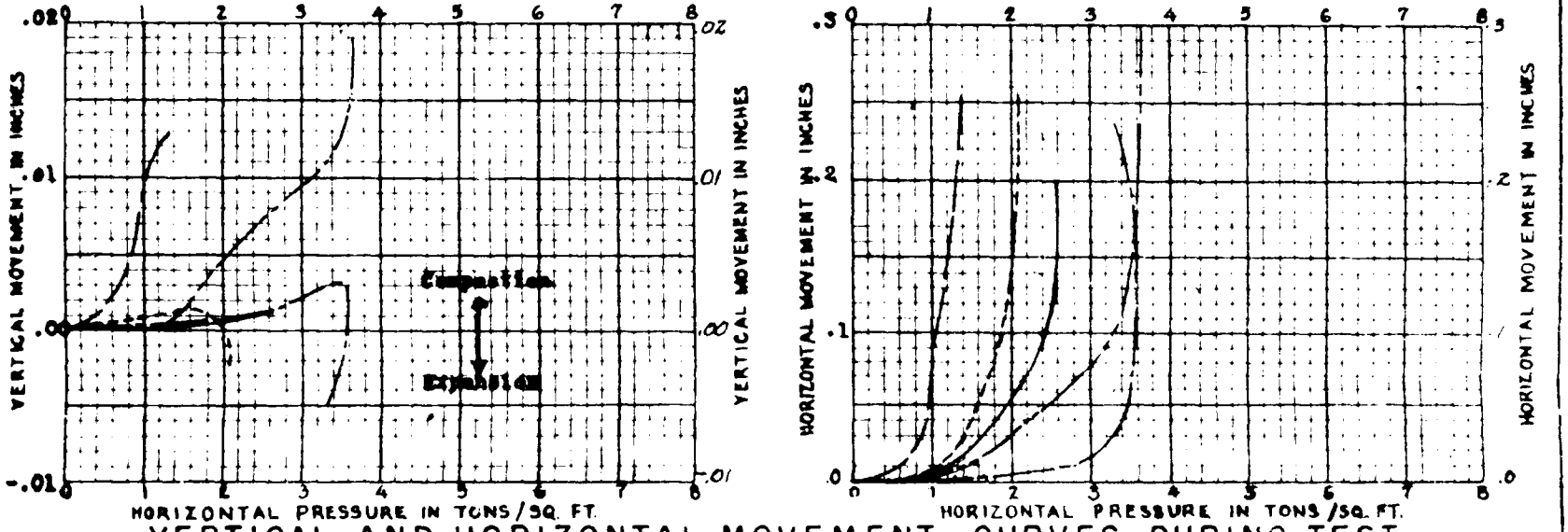
Submitted	Approval Recommended: Major, Corps of Engineers	Approved: Col. Corps of Engineers
Drawn by: DWS	Traced by: EC	Checked by: OA
Transmitted with report dated	File No	

SHEET 26

G.P.O.—160810



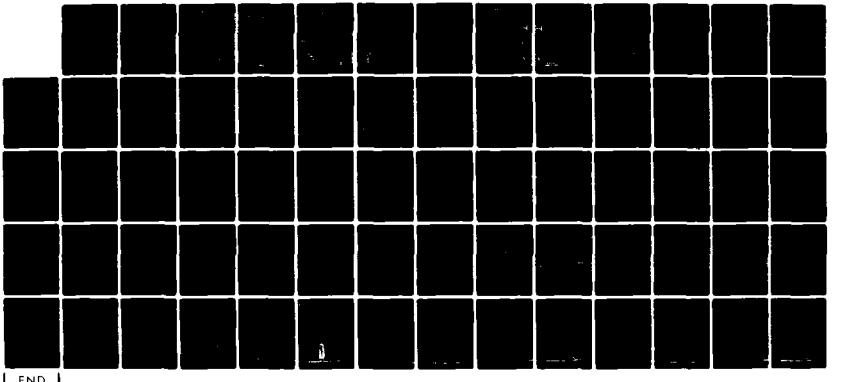
MECHANICAL ANALYSIS CURVE OF SOIL TESTED



VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST

AD-A123 608 EMBANKMENT CRITERIA AND PERFORMANCE REPORT MISSOURI RIVER FORT PECK LAKE MONTANA VOLUME II DRAWINGS(U) ARMY ENGINEER DISTRICT OMAHA NEBR SEP 82 2/2

UNCLASSIFIED F/G 13/13 NL



END
DATE FILMED
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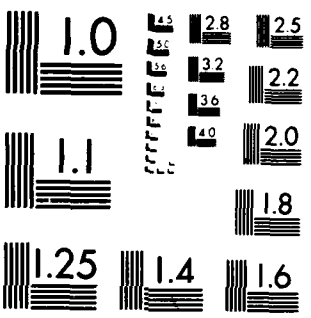
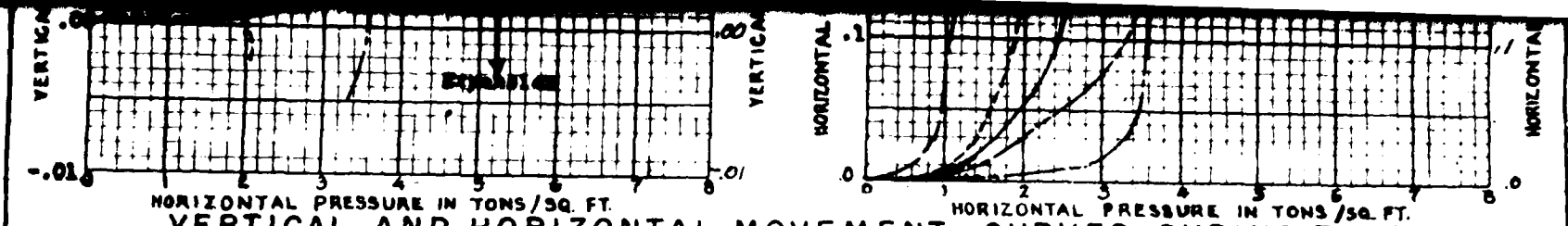
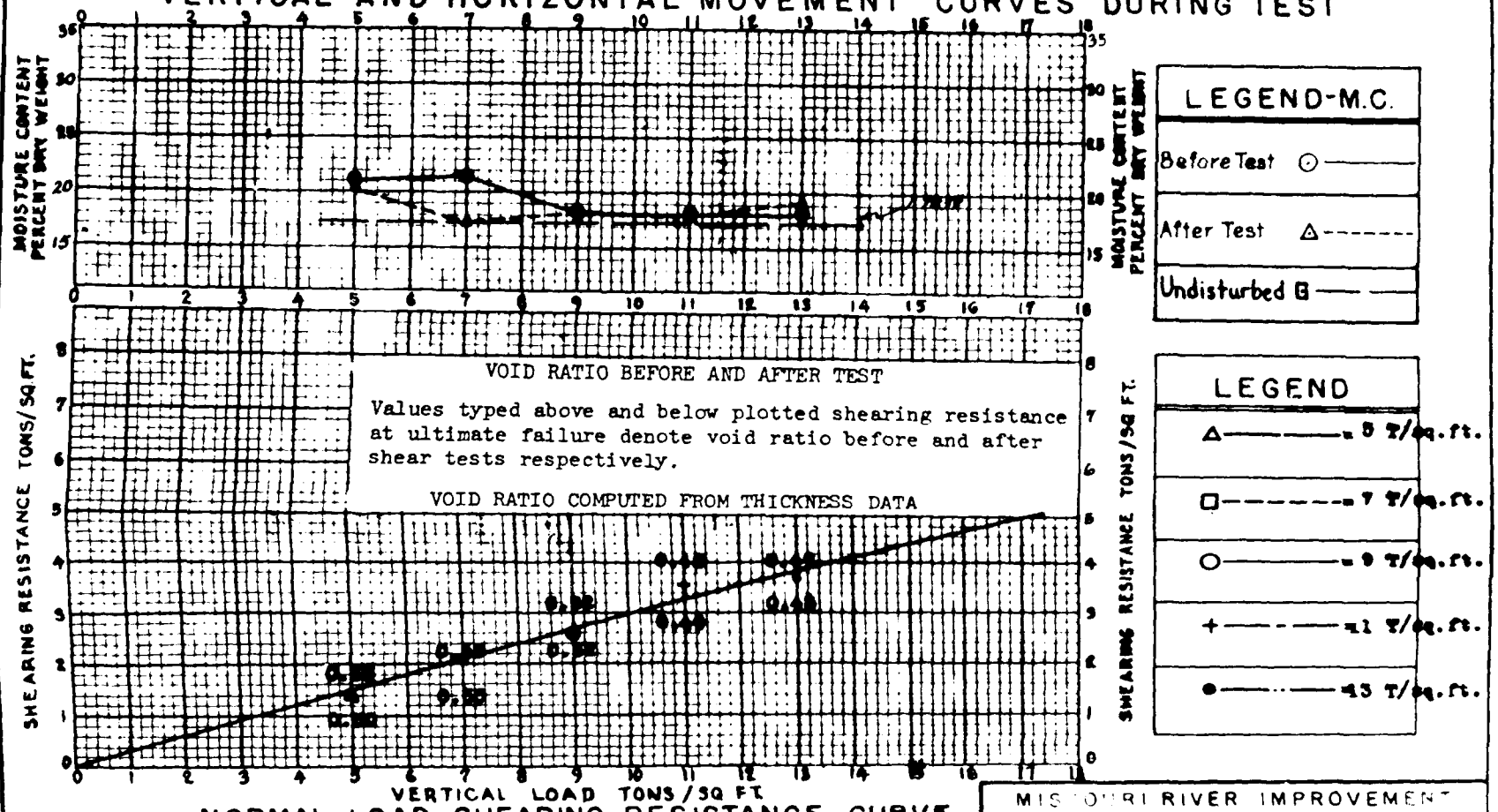




VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



LEGEND-M.C.

- Before Test ⊙——
- After Test △- - - - - -
- Undisturbed ⊡ —— ——

LEGEND

- △——— = 5 T/sq.ft.
- □- - - - - = 7 T/sq.ft.
- ○——— = 9 T/sq.ft.
- +—— - —— = 11 T/sq.ft.
- ●——·——·—— = 13 T/sq.ft.

NORMAL LOAD-SHEARING RESISTANCE CURVE

$\tan\phi = \frac{\text{Shearing Resistance} - \text{Cohesion (Tons/Sq Ft)}}{\text{Vertical Load (Tons/Sq Ft)}} = 0.294$

$\phi = 16°23'$

$c = \text{Cohesion} = 0.0\text{T/sq.ft.}$

Notes

Undisturbed Sample
Consolidates shear tests
Delta Loading
Cross Sectional Area of Sample 10.00 sq. in
Initial Thickness 0.75 inch
Sample Immersed in Water During Test
Note: Sample taken from block of soft shale in weathered zone in drift above inlet portals.

MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

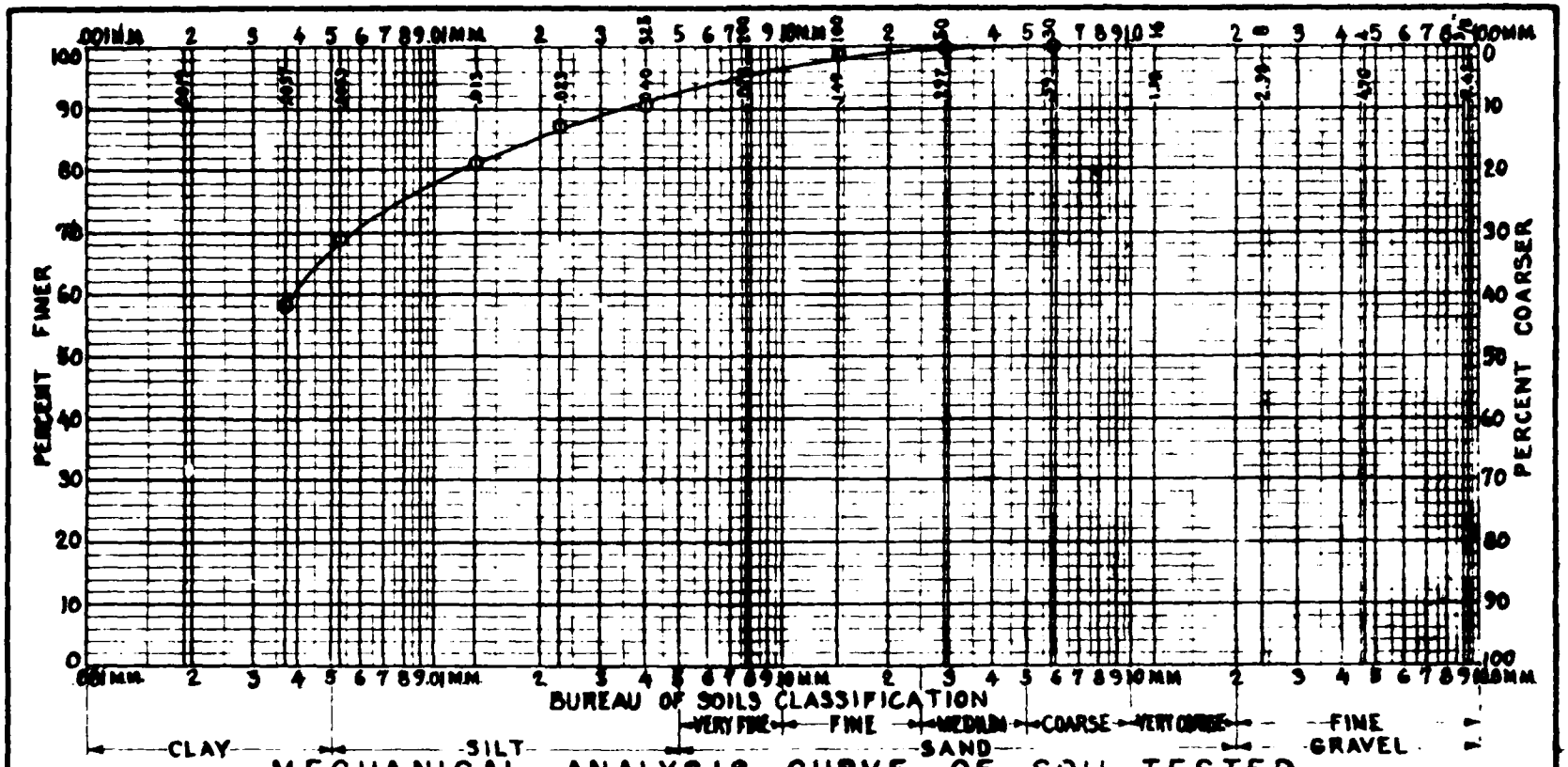
SLIDE INVESTIGATION

CONSOLIDATED SHEAR TESTS SERIES # 1°

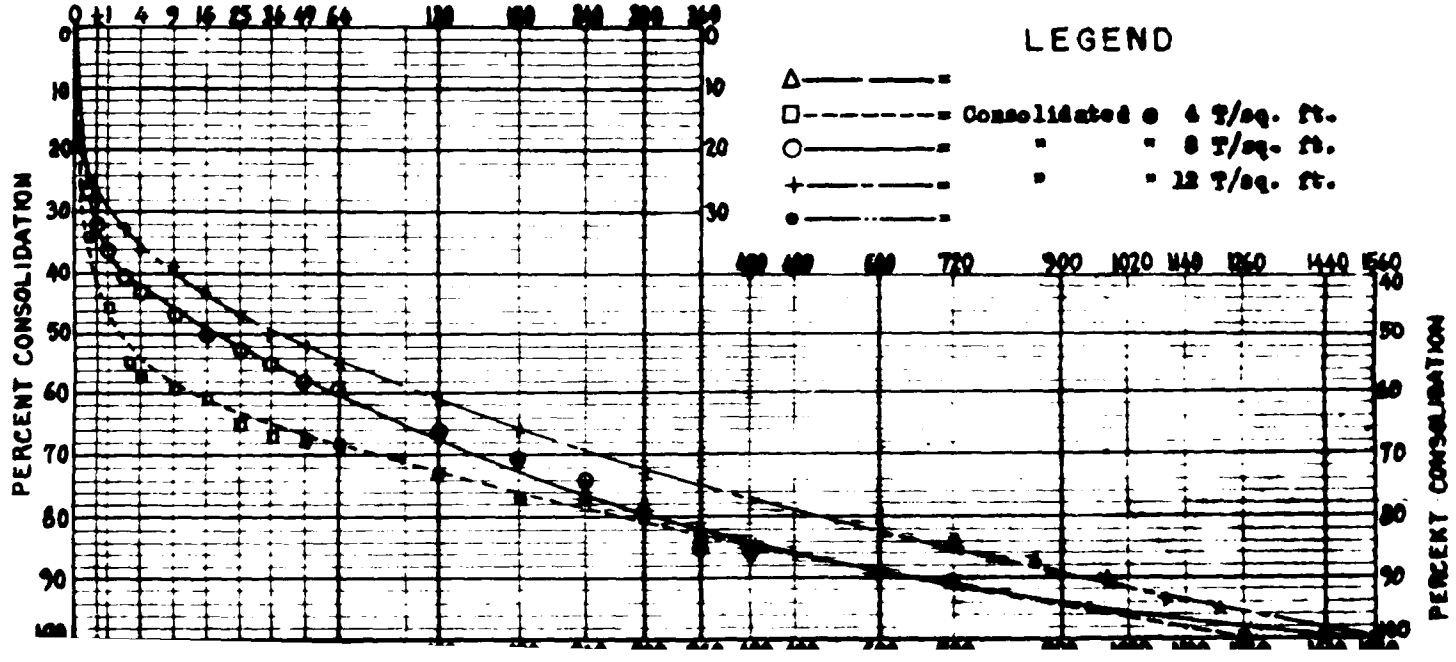
UND. WEATHERED SHALE--INLET PORTALS.

MERIDIAN DRIFT

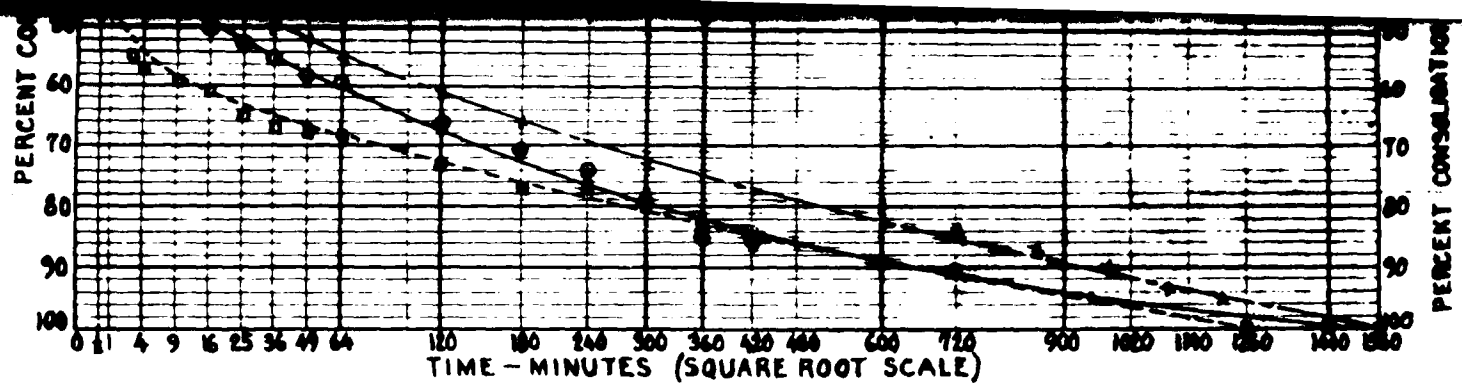
			Approved
Drawn J.L.	Traced B.C.	Checked by D.R.D.	Transmitted with report



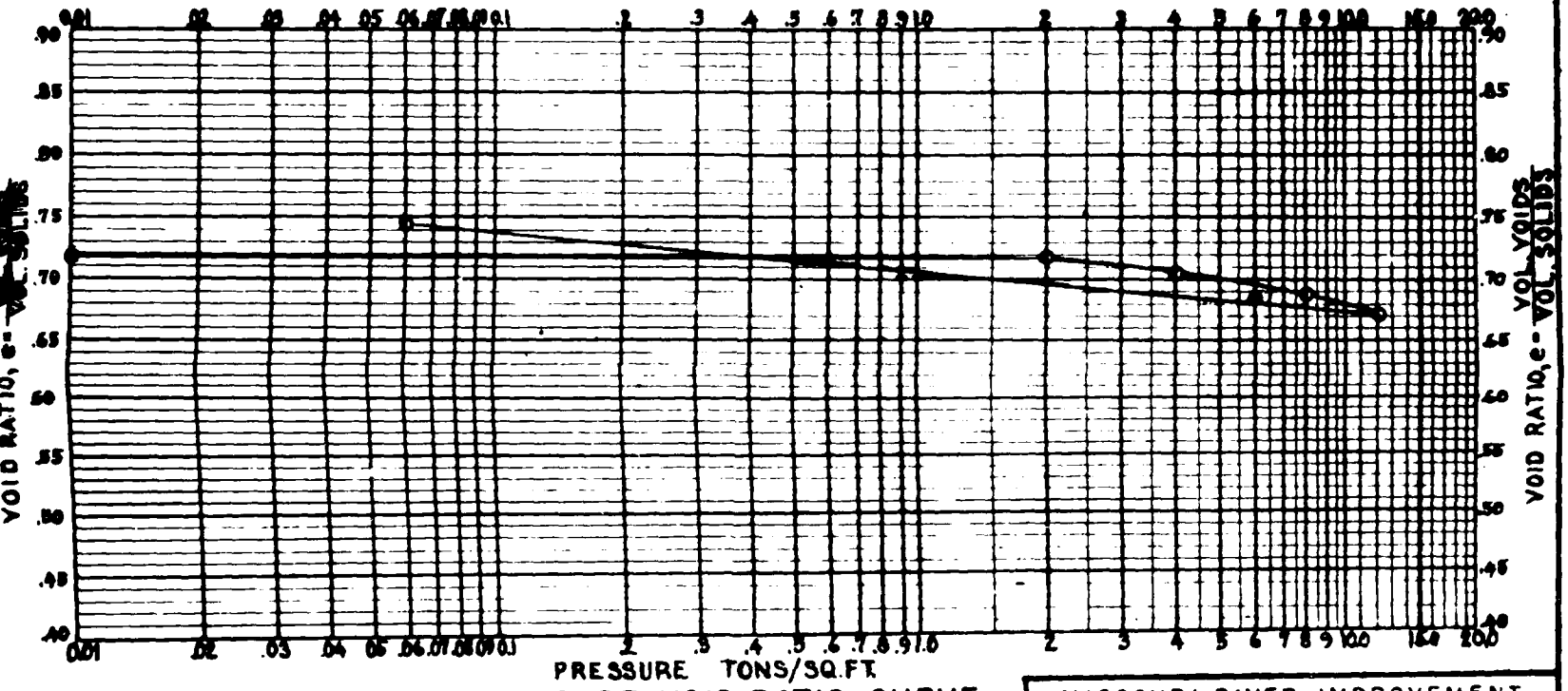
MECHANICAL ANALYSIS CURVE OF SOIL TESTED



FORT



TIME–PERCENT CONSOLIDATION CURVES



PRESSURE–VOID RATIO CURVE

Estimated Previous Consolidation = ... Tons/Sq.Ft.

Undisturbed sample of Weathered shale from Merriman Drift above Inlet Portals.
Immersed in Water during Test.
Initial Thickness 1.25 inches.
Cross Sectional Area 24.80 sq. in.

VERTICAL LOAD TONS/SQ.FT.	COMPACTION PERCENT*
0.00	0.00
2.00	0.08
4.00	0.80
8.00	1.92
12.00	2.04
6.00	2.24
0.07	- 1.28

* Total compaction in percent of original height of sample.

MISSOURI RIVER IMPROVEMENT
NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION

FORT PECK DAM
SLIDE INVESTIGATION
CONSOLIDATION TEST WEATHERED SHALE
MERRIMAN DRIFT; SAMPLE #1

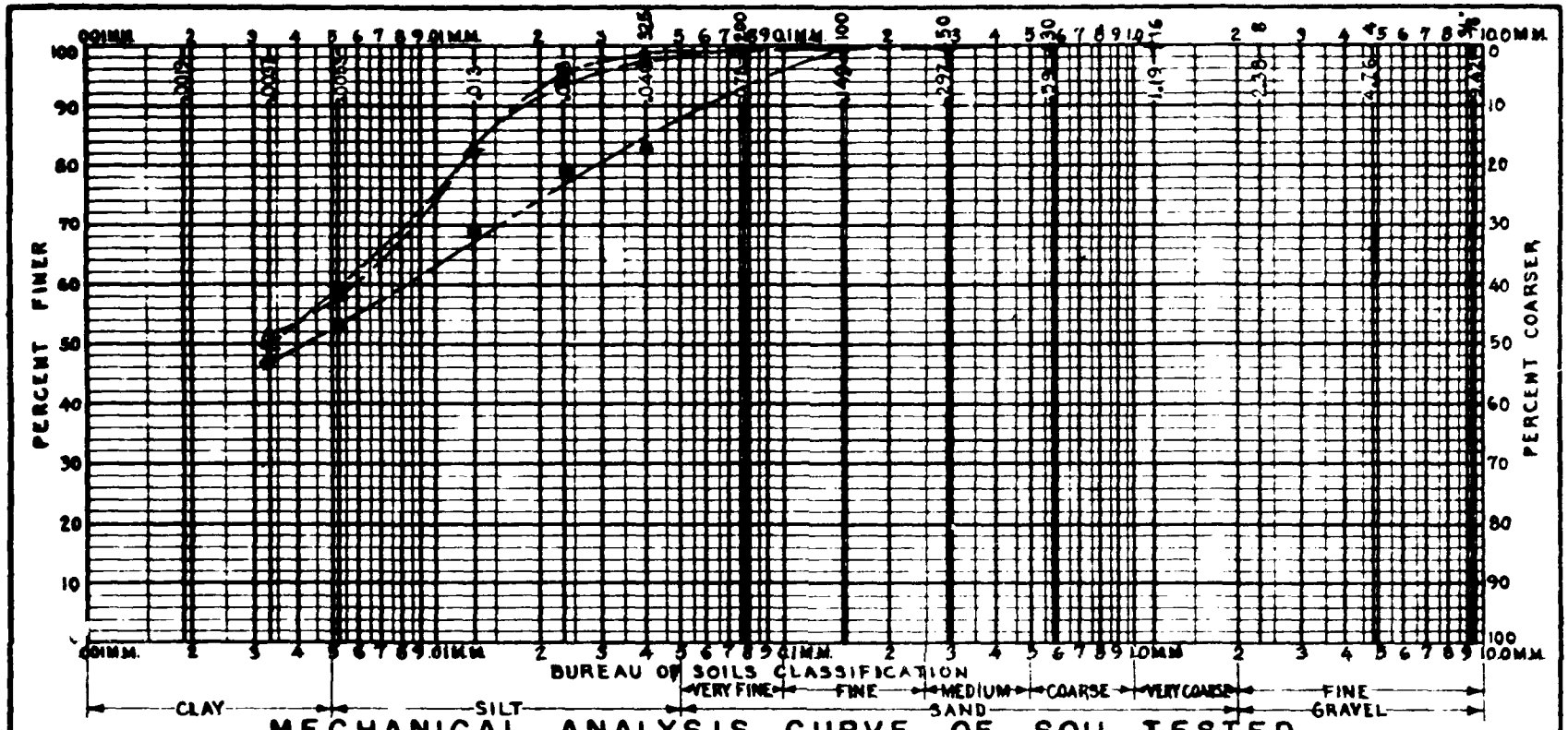
U S ENGINEER OFFICE, FORT PECK, MONT. 1-20-38

Submitted	Approval Recommended:	Approved.
.....	Major General, Chief of Engineers	Brig. General, Chief of Engineers

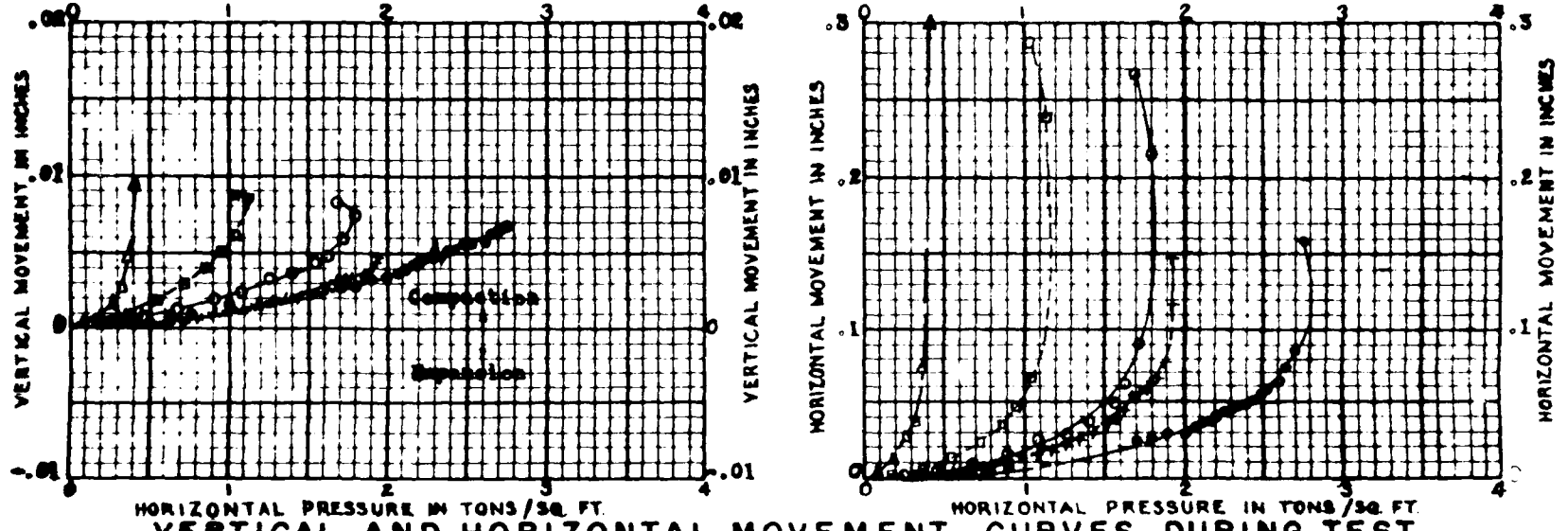
Drawn by	Traced by	Checked by:	Transmitted with report dated	File No.
DWS	EBC			

SHEET 28

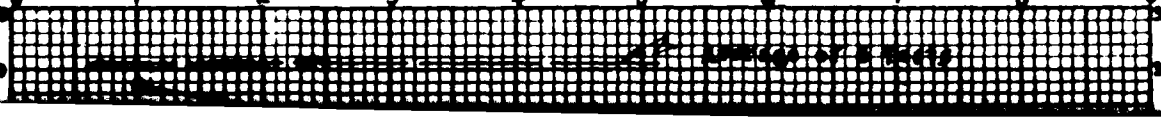
G P O — 180810



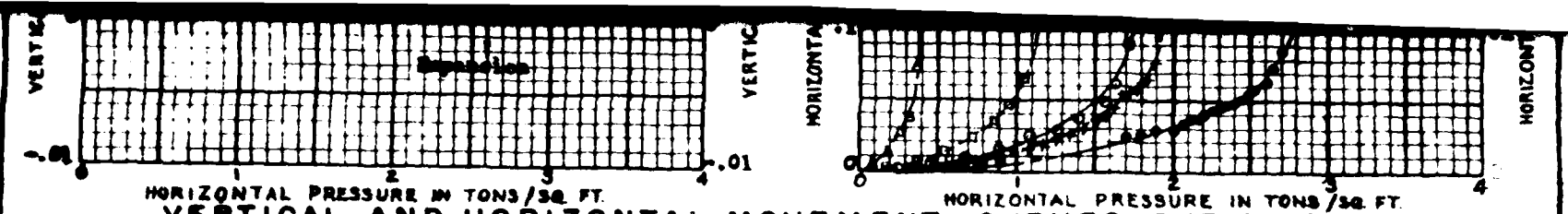
MECHANICAL ANALYSIS CURVE OF SOIL TESTED



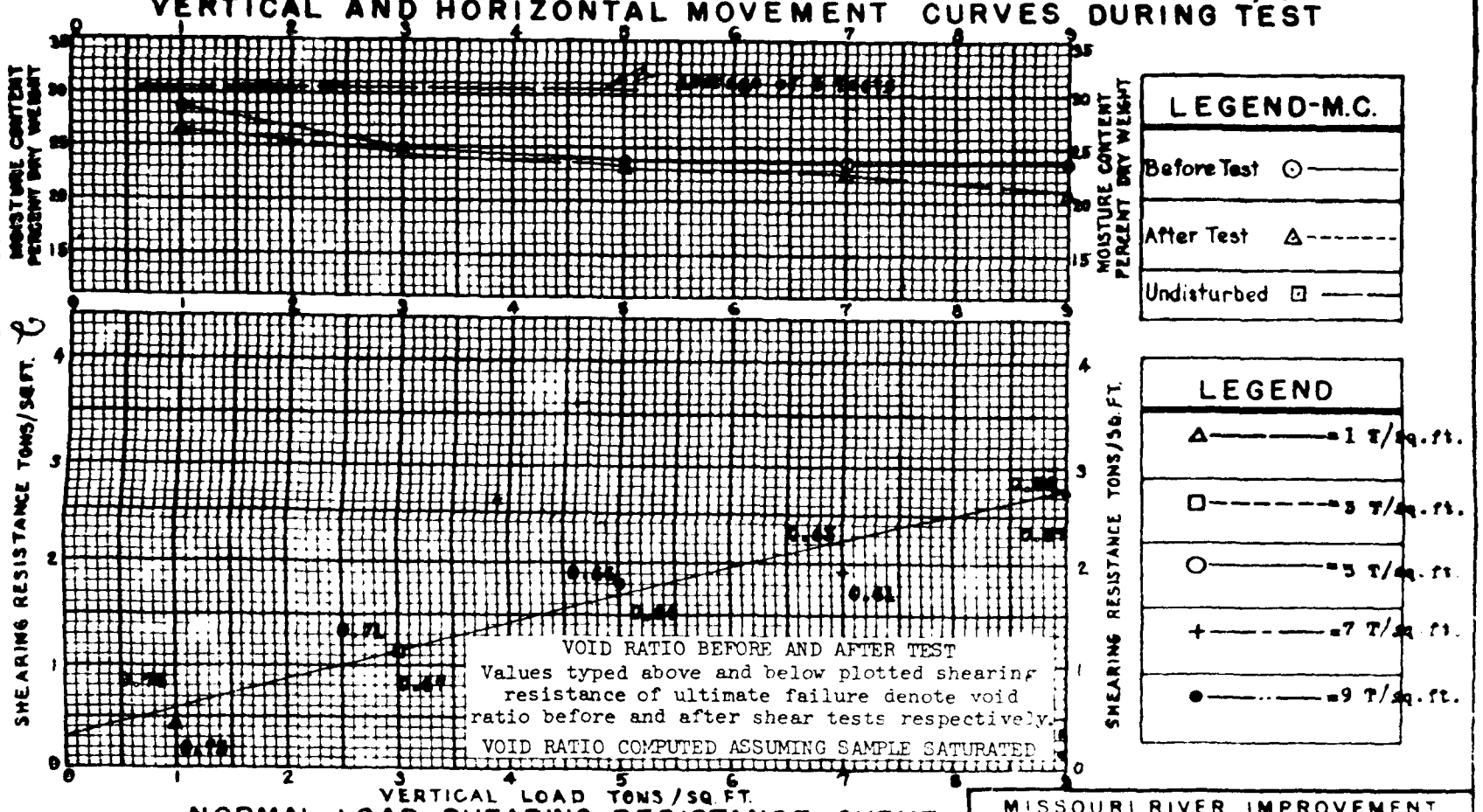
VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



LEGEND-M.C.



VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



NORMAL LOAD-SHEARING RESISTANCE CURVE

tan φ = Shearing Resistance − Cohesion (Tons/Sq.Ft.) / Vertical Load (Tons/Sq.Ft.) = 0.275

φ = 15° 25'

c = Cohesion = 0.80 T/sq.ft.

Notes: Undisturbed Sample
Consolidated Shear Tests
Increment Loading
Elevation 2115.0 - 2114.0
Depth 0.0 - 1.0
Cross Sectional Area of Sample 10.00 Sq. In.
Initial Thickness 0.75 inch
Sample immersed in water during test
Station 13 + 5 Range 14 + 50

MISSOURI RIVER IMPROVEMENT
NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION
FORT PECK DAM
SLIDE INVESTIGATION
SHEAR TESTS ON UNDISTURBED SAMPLES OF DISTURBED WEATHERED SHALE
U.S. ENGINEER OFFICE, FORT PECK, MONT. 1-4-39

Submitted	Approval Recommended	Approved
	Major Corps of Engineers	Division Engr. of Engineers

Drawn by	Traced by	Checked by	Transmitted with report dated	File No.
JLB	KBC	KBC		

Results of tests on undisturbed samples of shale taken in the Fort Peck Dam Foundation, downstream, with 6-inch sampler

(Original sheets 30-31)

1	2	3	4	5	6	7	8	9
Sample No.	Sand overburden	Depth into shale	Equivalent load in tons/sq. ft.	Moisture content, percent dry weight	Shearing strength in tons/sq. ft.	Computed shearing strength tons/sq. ft. with Tanϕ = 18, C = .20	Ratio $\frac{6}{7}$	Type test
HOLE C-12 STATION 10+75, RANGE 8+00 D								
6	14.6	1.4	0.85	31.2	0.65	0.35	1.85	Quick.
7	14.6	3.4	.97	23.8	.86	.37	2.32	Consol.
8	14.6	5.4	1.09	25.3	.89	.40	2.2	Quick.
9	14.6	7.4	1.21	30.6	.81	.42	1.93	Quick.
HOLE C-13 STATION 12+00, RANGE 8+00 D								
2	26.5	0.6	1.39	28.0	1.39	0.43	2.9	Quick.
3	26.5	0.9	1.29	27.7	1.06	.43	2.5	Consol.
4	26.5	2.9	1.44	48.5	.94	.45	2.1	Quick.
5	26.5	4.9	1.53	26.0	2.06	.48	4.3	Quick.
6	26.5	6.9	1.65	25.5	1.13	.39	2.3	Quick.
7	26.5	8.9	1.65	28.0	1.55	.39	3.1	Consol.
8	26.5	10.4	1.90	25.0	1.28	.54	2.3	Quick.
9	26.5	12.0	2.01	[1] 26.0	1.26	.56	2.3	Quick.
HOLE C-14 STATION 12+80, RANGE 8+00 D								
2	46.3	1.7	2.48	29.0	2.25	0.65	3.5	Quick.
3	46.3	3.7	2.60	24.5	1.39	.67	1.9	Consol.
4	46.3	5.7	2.72	21.2	2.4	.69	3.5	Quick.
5	46.3	7.7	2.84	20.2	1.98	.71	2.7	Quick.
6	46.3	16.3	3.16	23.5	1.50	.77	1.95	Quick.
HOLE C-15 STATION 13+25, RANGE 8+00 D								
2	71.5	2.0	3.87	25.5	1.39	0.99	1.55	Quick.
3	71.5	3.5	3.96	[1] 26.7	1.51	.92	1.64	Consol.
5	71.5	7.75	4.21	25.5	2.59	.96	2.7	Quick.
7	71.5	11.75	4.46	25.0	2.05	1.05	1.96	Quick.
HOLE C-16, STATION 14+40, RANGE 8+00 D								
2	100	1.0	5.78	27.7	2.56	1.26	2.04	Quick.
3	100	3.0	5.90	27.1	3.02	1.26	2.40	Consol.
4	100	7.0	6.16	26.8	1.89	1.30	1.45	Quick.
TEST SHAFT, STATION 12+00, RANGE 8+00 D								
0	24.5	1.2	1.26	28.1	0.72	0.44	1.64	Quick.
1	24.5	1.3	1.26	31.1	.96	.44	2.13	Quick.
2	24.5	5.3	1.75	[1] 28.2	1.44	.52	2.77	Quick.
GLACIAL TILL FROM HOLE AT STATION 105+00, RANGE 0+95 D								
3	40.5	3.5	2.34	18.7	1.36	0.83	1.64	Quick.
4	40.5	5.5	2.46	19.6	1.36	.86	1.62	Quick.
5	40.5	7.5	2.58	20.4	1.49	.89	1.67	Consol.
6	40.5	9.5	2.70	17.8	1.44	.93	1.57	Quick.

[1] After test.

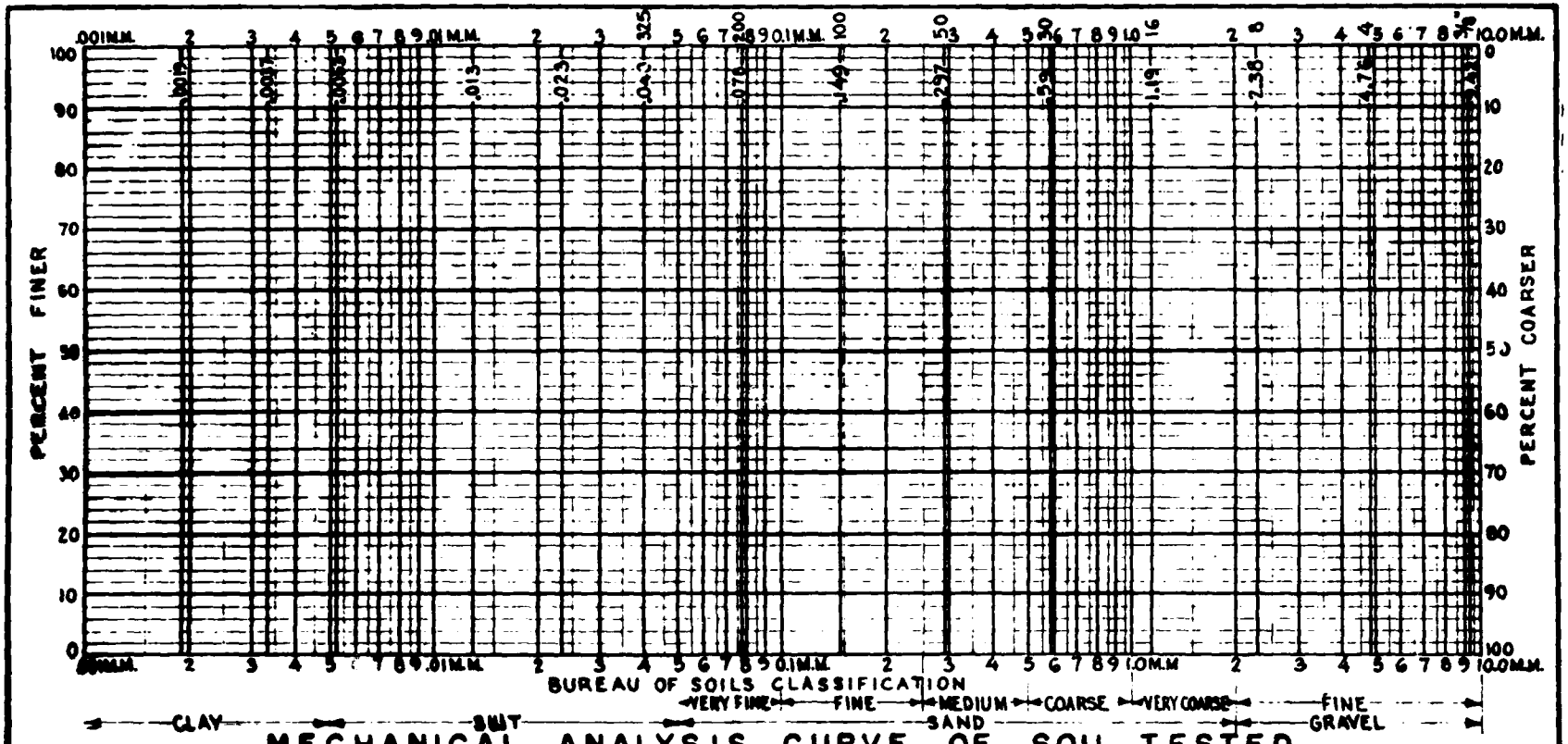
NOTES.—Except for samples 1 and 2 from the test shaft all samples were 6" drive samples.

Duration of test for Quick shear varied from 1.5 to 3 minutes.

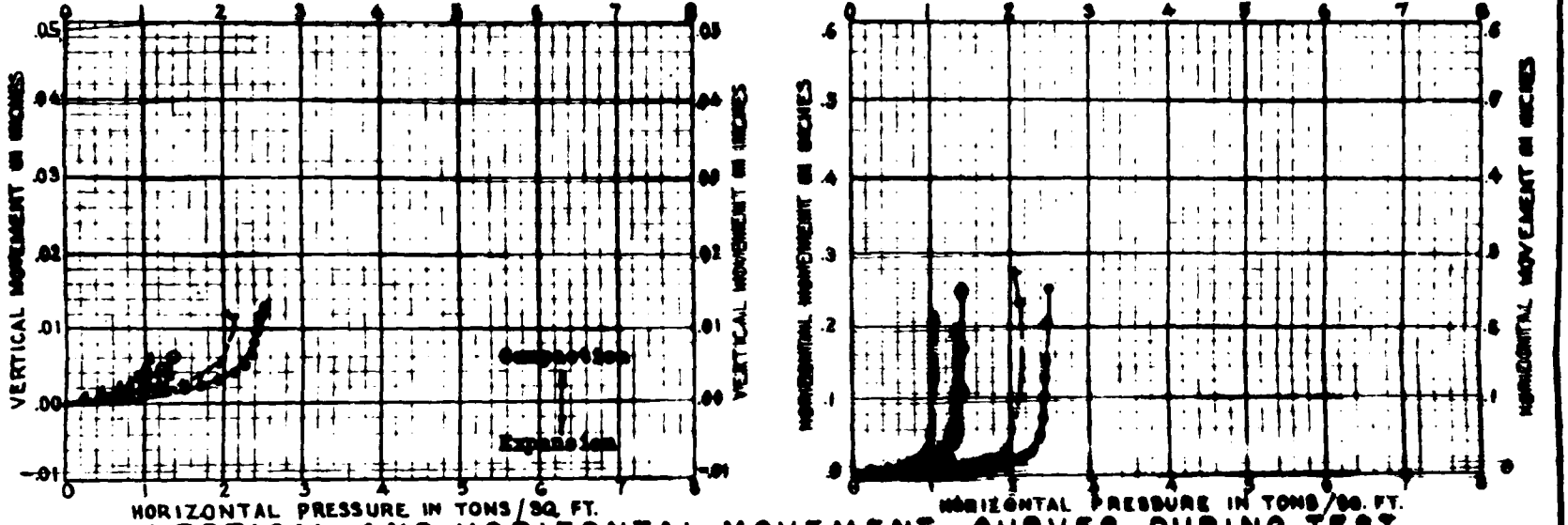
The vertical load for the duration of the test was as indicated in Column 4.

Tan ϕ=0.18, C=0.20 were coefficients used in the design of the reconstruction in the slide area.

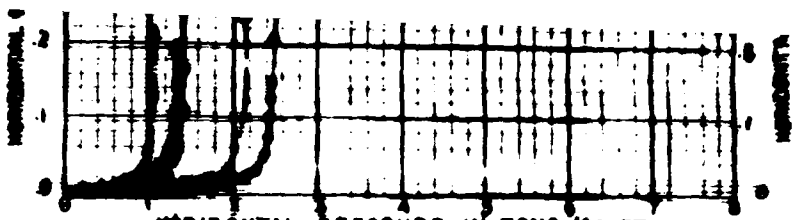
For computed shearing strength for Glacial Till from Hole S. D. 105/0.95 coefficients used were Tan. ϕ=.26, C=.22.



MECHANICAL ANALYSIS CURVE OF SOIL TESTED



VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST

LEGEND-M.C.

Before Test ⊙——

After Test △- - - - - -

Undisturbed ⊡——

LEGEND

△——— = 5 T/sq.ft.

□- - - - - - = 8 T/sq.ft.

○——— = 10 T/sq.ft.

+——-——= 12 T/sq.ft.

●——·——= 15 T/sq.ft.

NORMAL LOAD-SHEARING RESISTANCE CURVE

$\tan\phi = \frac{\text{Shearing Resistance - Cohesion (Tons/Sq.Ft.)}}{\text{Vertical Load (Tons/Sq.Ft.)}} = 0.155$

$\phi = 8° 50'$

c = Cohesion = 0.80 T/sq.ft.

Notes:
Undisturbed Sample
Consolidated Shear Tests
Increment Loading
Cross Sectional Area 16.00 sq. in.
Initial Thickness 0.75 inch.
Sample Immersed in Water during Test.

MISSOURI RIVER IMPROVEMENT
FLOOD CONTROL, POWER, IRRIGATION
FORT PECK DAM
SLIDE INVESTIGATION
CONSOLIDATED SHEAR TESTS - SERIES #1
BENTONITE FROM CROSBY DRIFT
DATE 1-27-39

			Approved
Drawn JLB	EBC		

PLATE S-29 STRENGTH CRITERIA AND PERFORMANCE REPORT

(Face p. 32) No. 1

G P O—160810

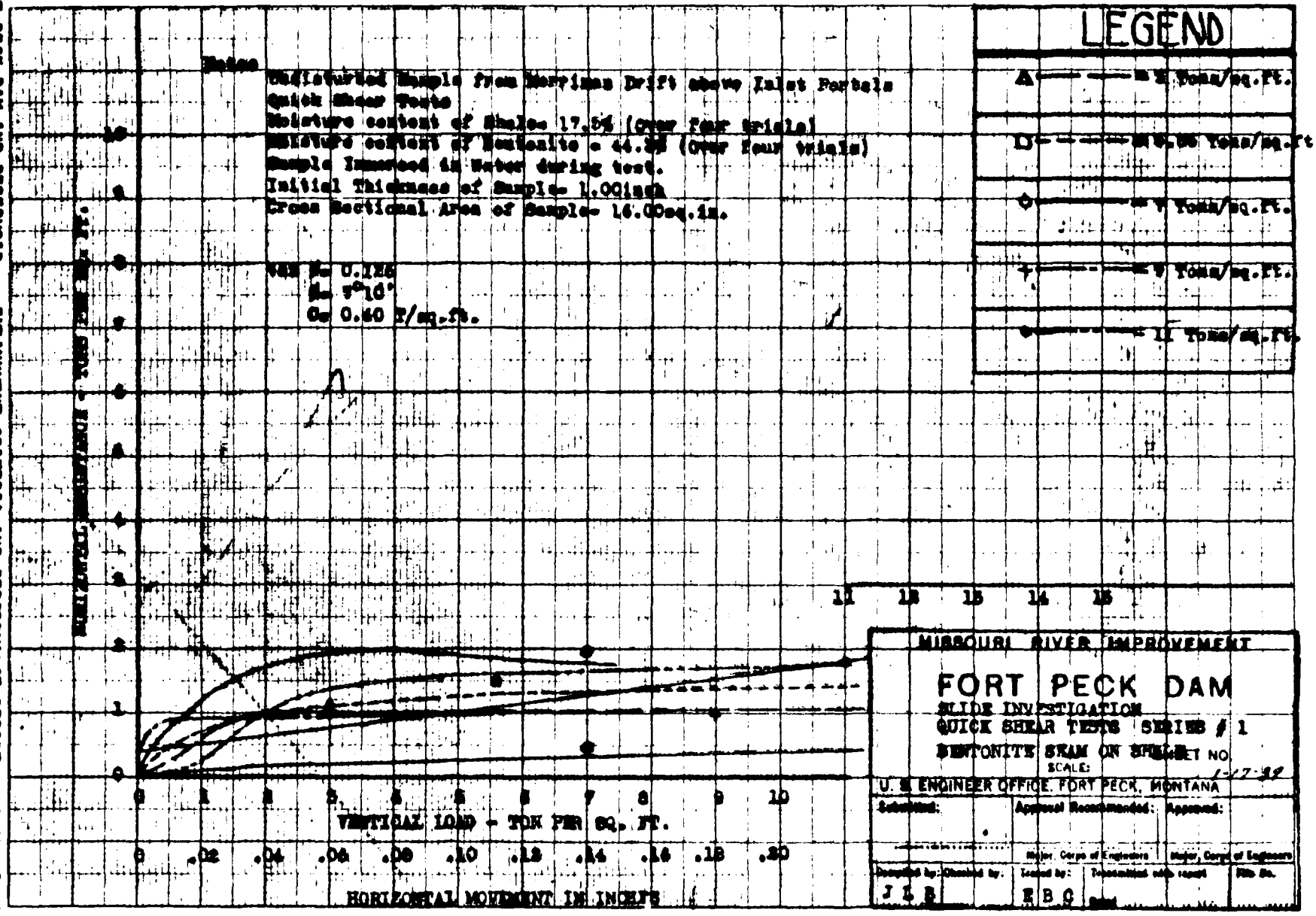

Below
Undisturbed Sample from Morrison Drift above Inlet Portals
Quick Shear Tests
Moisture content of Shales 17.5% (Over four trials)
Moisture content of Bentonite = 44.8% (Over four trials)
Sample Immersed in Water during test.
Initial Thickness of Sample= 1.00inch
Cross Sectional Area of Sample= 16.00sq.in.
Cu 0.60 T/sq.ft.
LEGEND
A = 8 Tons/sq.ft.
B = 9.25 Tons/sq.ft.
C = 9 Tons/sq.ft.
D = 9 Tons/sq.ft.
E = 11 Tons/sq.ft.
VERTICAL LOAD - TON PER SQ. FT.
HORIZONTAL MOVEMENT IN INCHES
MISSOURI RIVER IMPROVEMENT
FORT PECK DAM
SLIDE INVESTIGATION
QUICK SHEAR TESTS SERIES # 1
BENTONITE SEAM ON SPILLWAY SHEET NO.
SCALE:
1-17-39
U. S. ENGINEER OFFICE, FORT PECK, MONTANA
Major, Corps of Engineers
Major, Corps of Engineers
J E B
E B C

FIGURE 16.—Results of shear tests.

All tests are consolidated unless otherwise noted

Transition zone material:

Tan ϕ	c
0.712	0.0
0.640	0.0

Stratified material from Calyx No. 4:

Tan ϕ	c
0.520	0.0

Bentonite from Merriman drift:

Tan ϕ	c
0.136	0.40

Bentonite from Crosby drift:

Tan ϕ	c
0.155	0.20

Bentonite from Calyx No. 8 (Hard, impure bentonite, considerable volcanic ash):

Tan ϕ	c
0.247	0.90

Bentonite from near outlet portals:

Tan ϕ	c
0.241	0.70

Bentonite from Calyx No. 2:

Tan ϕ	c
0.139	0.80

Shale and bentonite from Calyx No. 4 (Sample consisted of fractured shale with the fractures filled with thin seams of bentonite):

Tan ϕ	c
0.180	0.80

Bentonite on shale (Field test material):

Quick shear	
Tan ϕ	c
0.120	0.0
0.126	0.4

Weathered shale:

a. Undisturbed sample of disturbed weathered shale in slide area:

Consolidated		Quick shear	
Tan ϕ	c	Tan ϕ	c
0.234	0.28	0.037	0.34
0.275	0.30	0.037	0.30
0.205	0.20	0.291	0.40

b. Gouge material from Crosby drift:

Tan ϕ	c
0.182 (quick shear)	0.20
0.210 (consolidated)	0.50

c. Sample taken from block of soft shale from weathered zone in Merriman drift at inlet portals:

Tan ϕ	c
0.302	0.40
0.282	1.00
0.294	0.00

d. Field Shear Test. Shale on bentonite.

Tan ϕ	c
0.151	0.05

e. Weathered shale from Calyx No. 2:

Tan ϕ	c
0.262	0.00

f. Undisturbed weathered shale from Calyx No. 3:

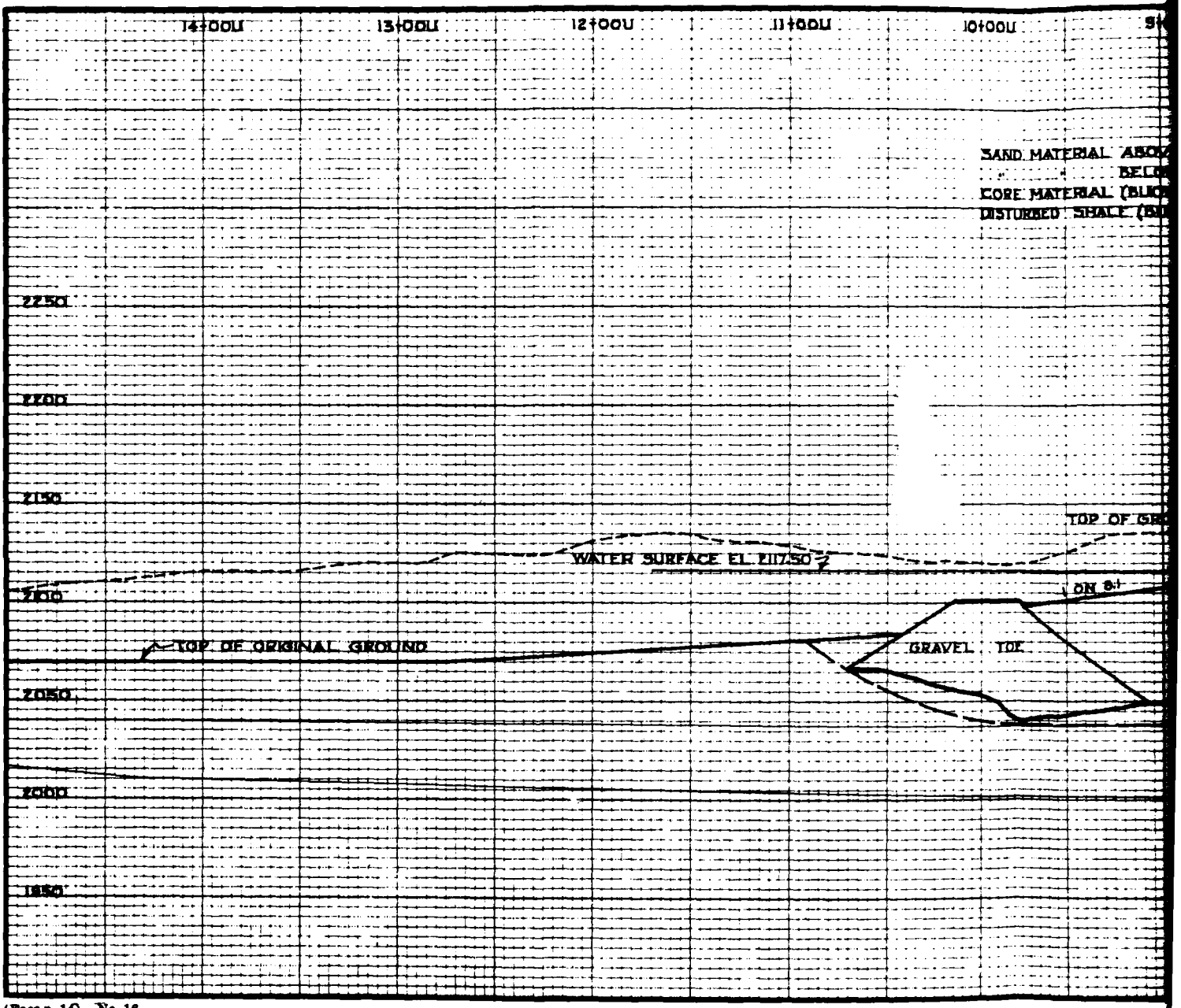
Tan ϕ	c
0.298	0.20

Surface clay:

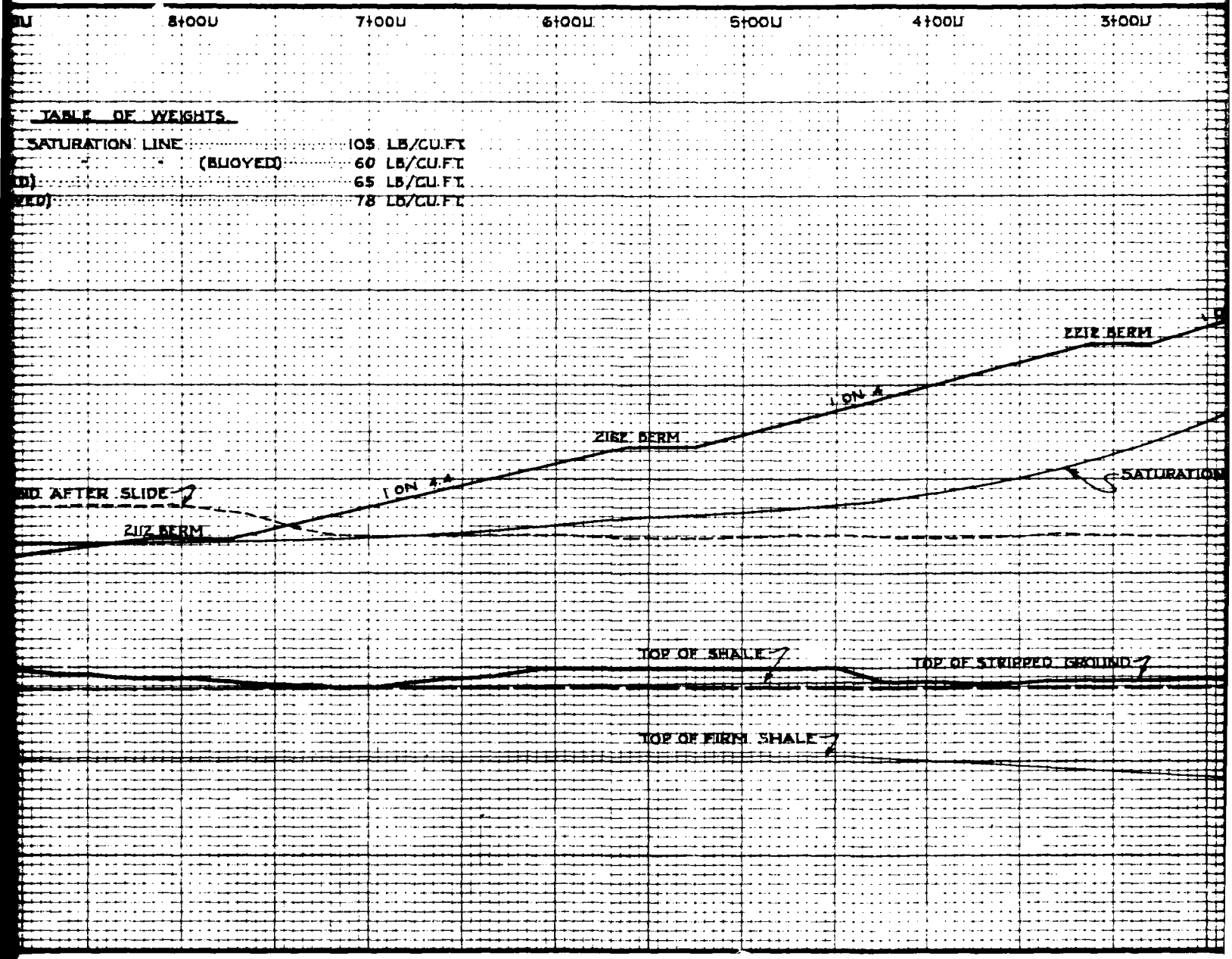
Consolidated		Quick shear	
Tan ϕ	c	Tan ϕ	c
0.210	0.40	0.067	0.25
0.153	0.50	0.014	0.41
0.158	0.50	0.014	0.40
		0.050	0.20
		0.051	0.31

CORE MATERIAL

Hole	Sample	Tan ϕ	Cohesion
C-7	3	0.633	0.0
	4	.702	0.0
	5	.564	0.0
	6	.675	0.0
	8	.694	0.0
	18	.579	0.0
	19	.737	0.0
	22	.668	0.0
	28	.698	0.0
	36	.367	0.15
	40	.616	0.00
	45	.656	0.00
	50	.533	0.20
	55	.607	0.10
	60	.750	0.00
	64	.684	0.00
	76	.655	0.00
	80	.682	0.05
C-8	1	.485	0.00
	2	.705	0.00
	3	.687	0.00
	10	.727	0.00
	14	.463	0.10
	17	.741	0.00
	19	.628	0.00
	22	.787	0.00
	29	.575	0.00
	34	.500	0.10
	39	.673	0.00
	44	.673	0.05
	49	.667	0.00
	53	.667	0.00
	57	.610	0.00
	58	.750	0.00
	67	.750	0.00
C-9	1	.482	0.1
	3	.992	0.0
	6	.585	0.2
	8	.414	0.22
	12	.631	0.0
	17	.714	0.0
	21	.547	0.0
	27	.628	0.0



(Face p. 14) No. 16


8+00U
7+00U
6+00U
5+00U
4+00U
3+00U
TABLE OF WEIGHTS
SATURATION LINE ..... 105 LB/CU.FT.
(BUOYED) ..... 60 LB/CU.FT.
65 LB/CU.FT.
78 LB/CU.FT.
2212 BERM
1 ON 4
2182 BERM
SATURATION
1 ON 4.4
2112 BERM
TOP OF SHALE
TOP OF STRIPPED GROUND
TOP OF FIRM SHALE

2

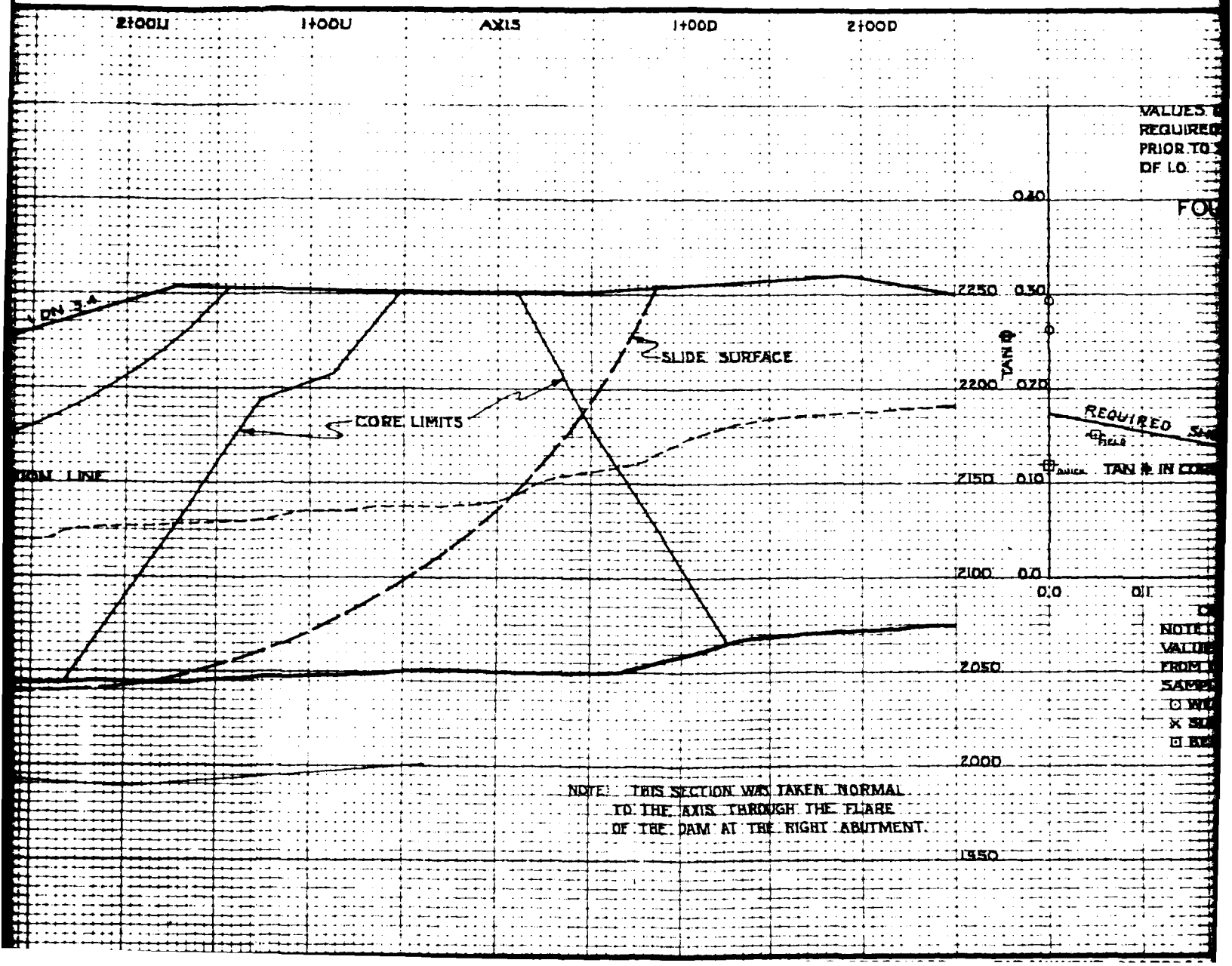
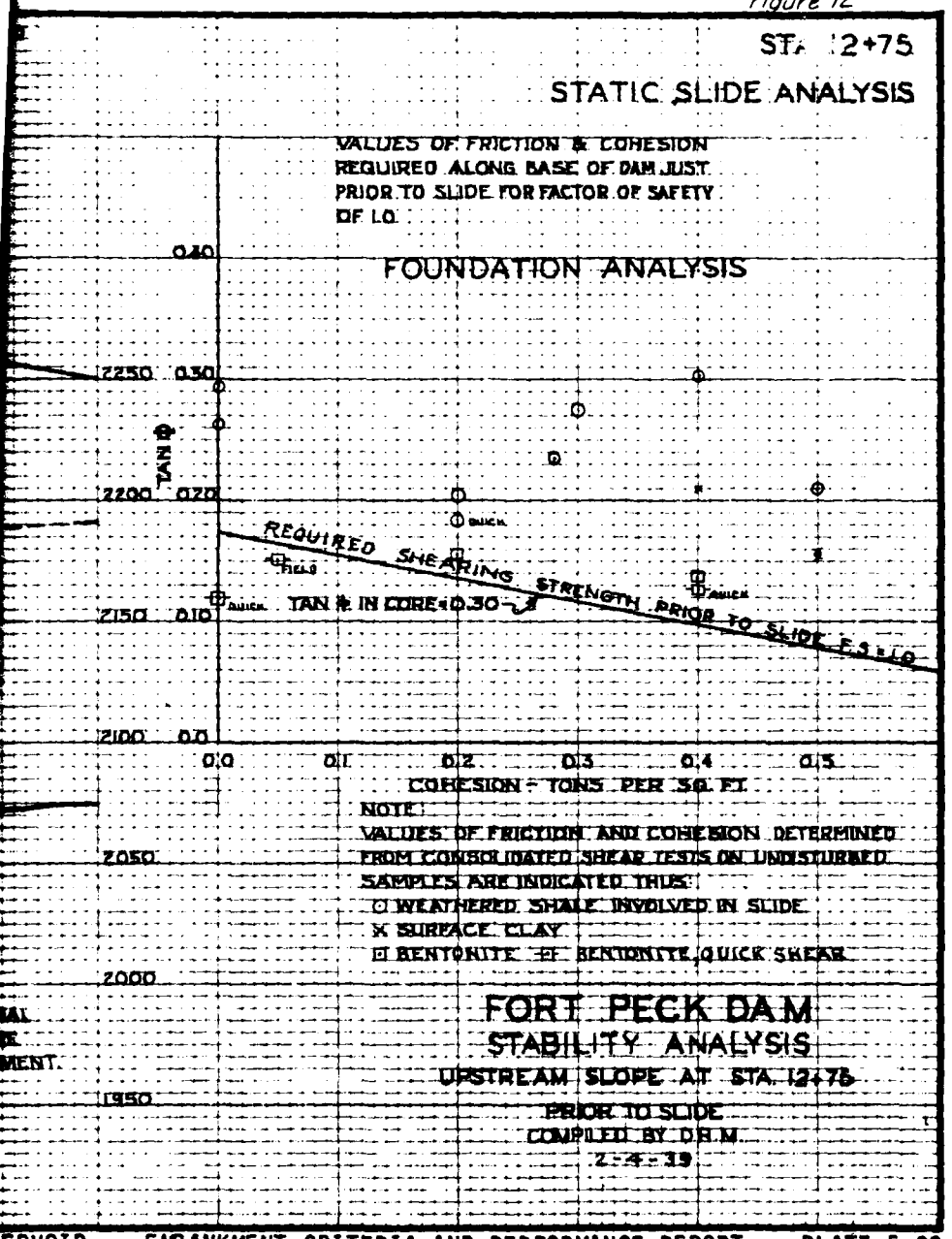
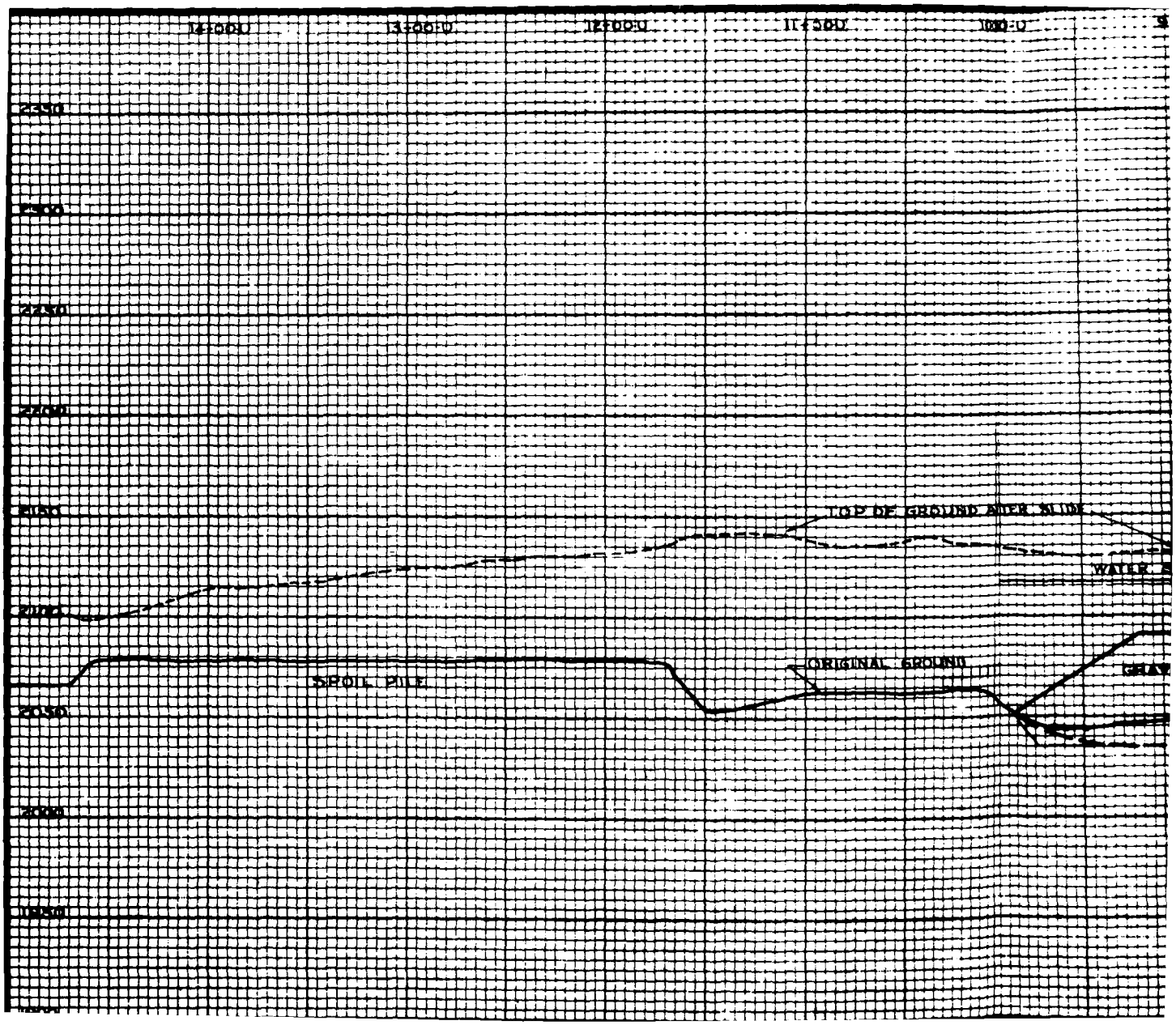
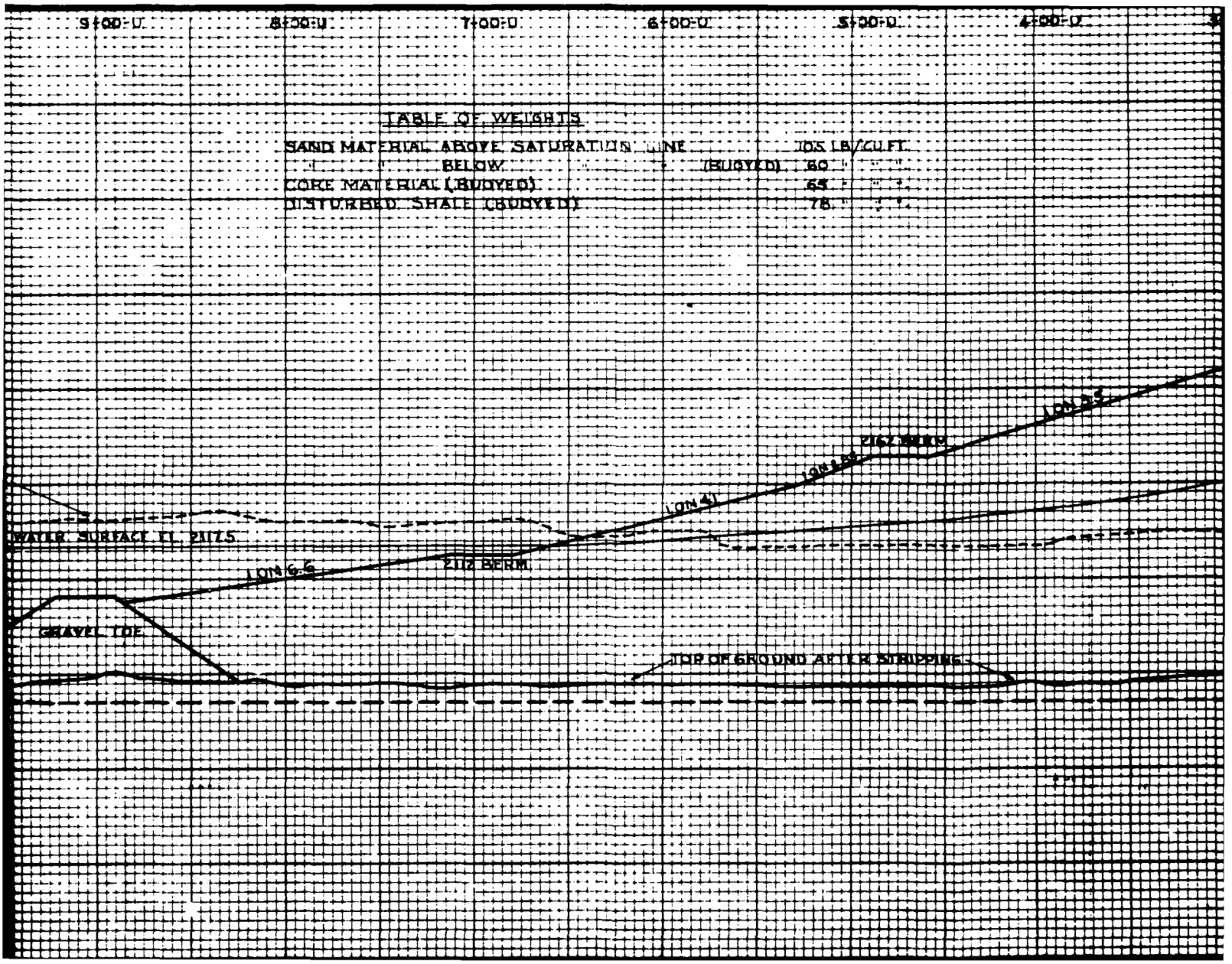
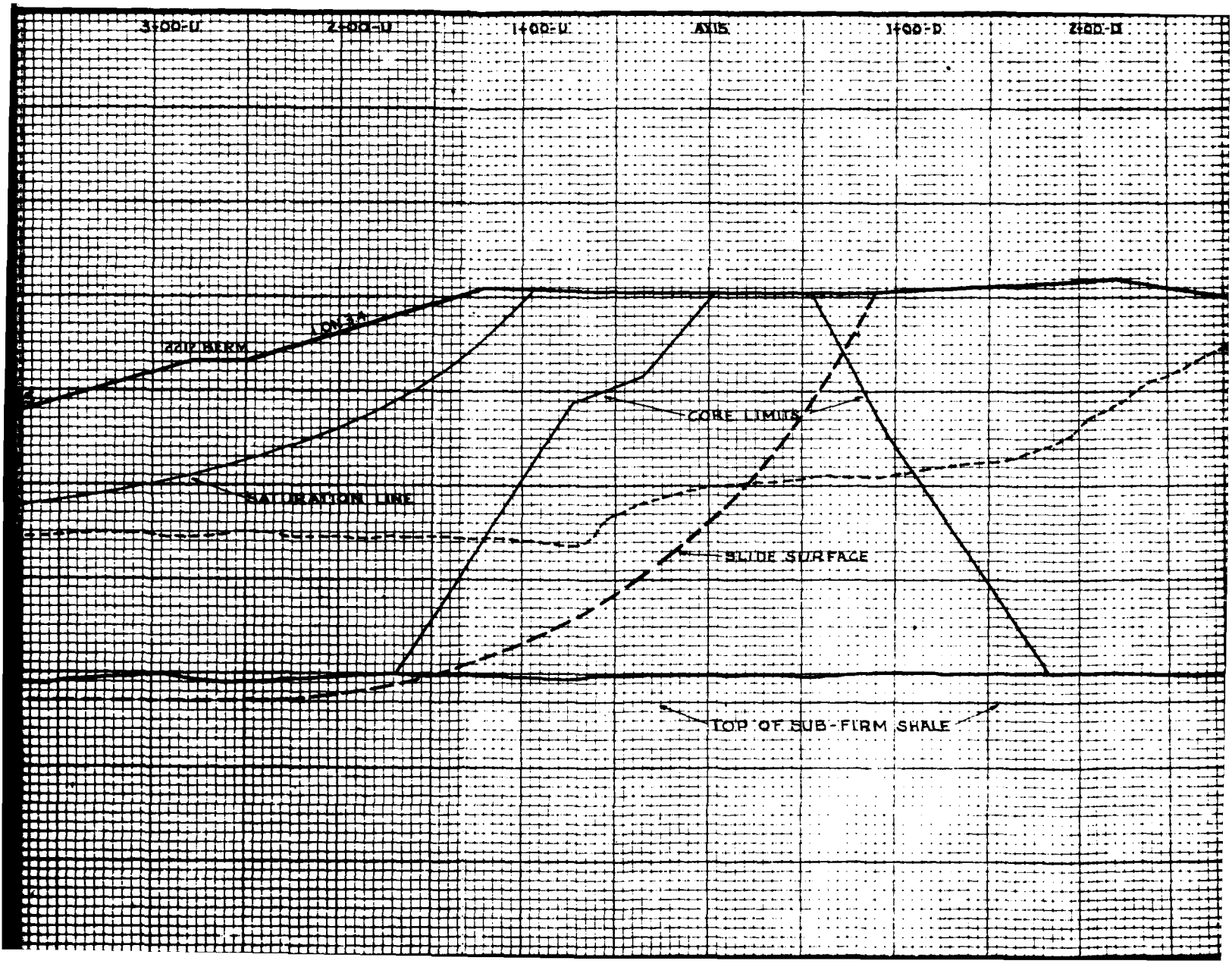

2+00U
1+00U
AXIS
1+00D
2+00D
SLIDE SURFACE
CORE LIMITS
2250
2200
2150
2100
2050
2000
1950
0.40
0.30
0.20
0.10
0.0
TAN Φ
REQUIRED
NOTE: THIS SECTION WAS TAKEN NORMAL
TO THE AXIS THROUGH THE FLARE
OF THE DAM AT THE RIGHT ABUTMENT.

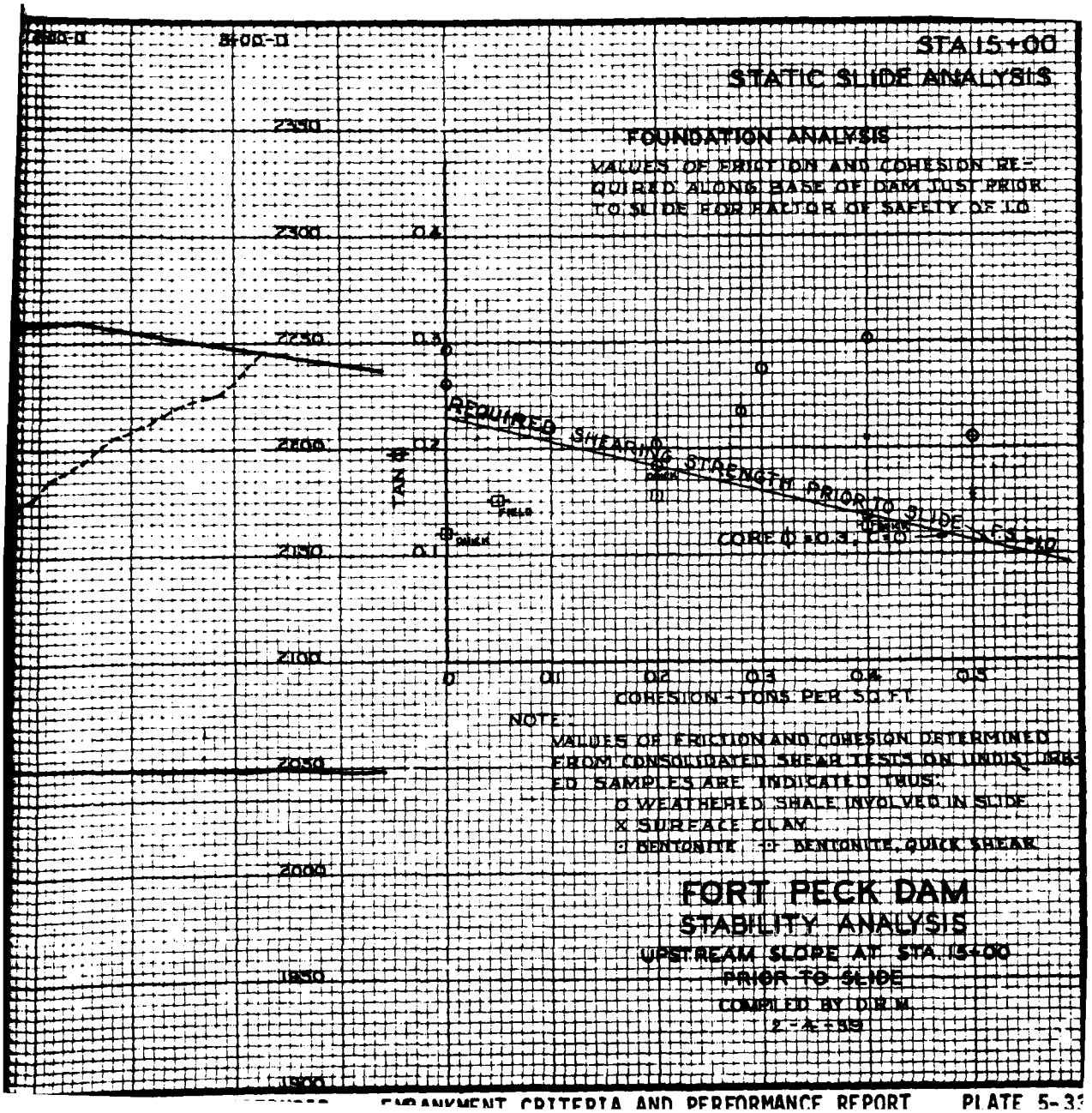
Figure 12

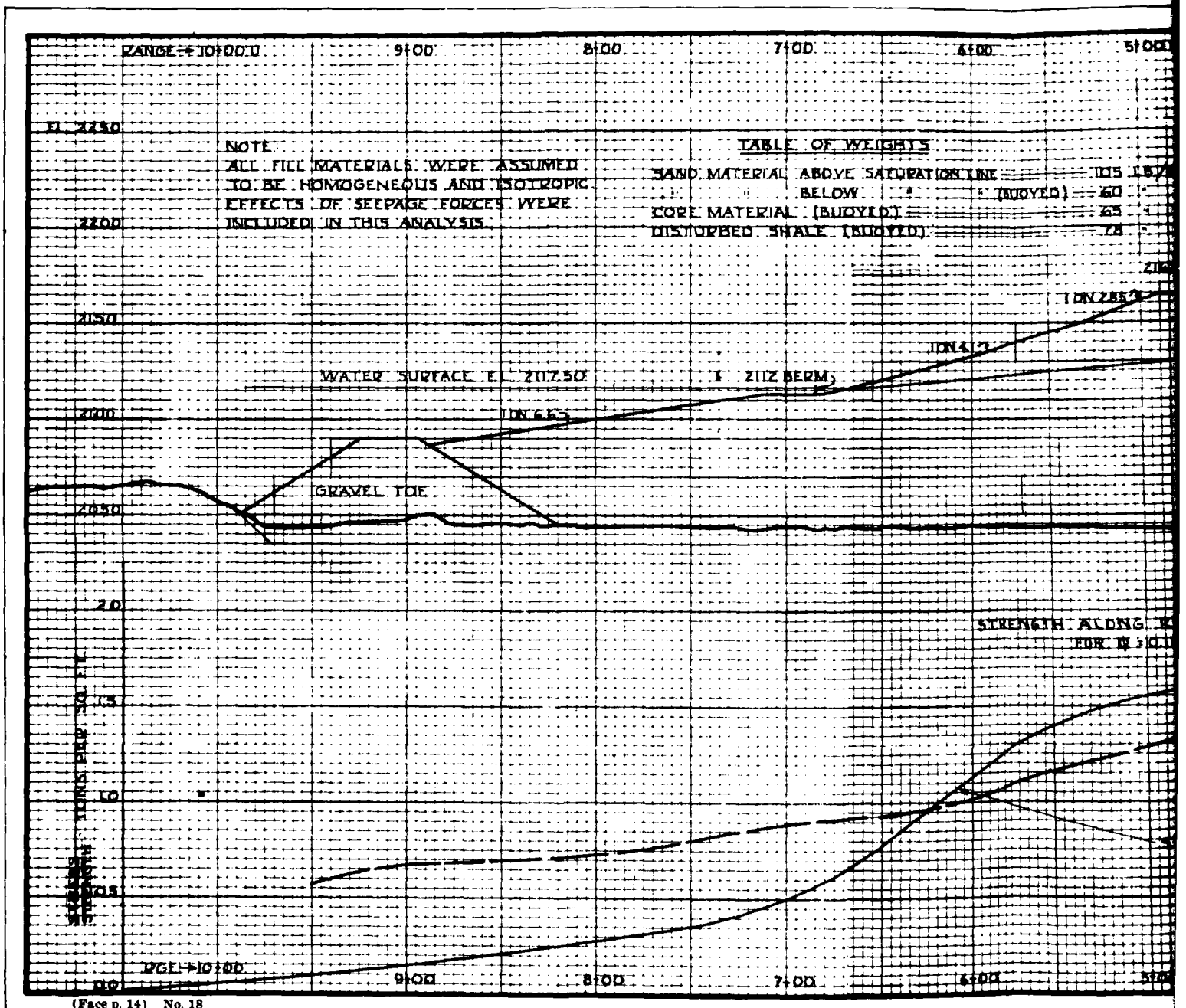

STA 12+75
STATIC SLIDE ANALYSIS
VALUES OF FRICTION & COHESION
REQUIRED ALONG BASE OF DAM JUST
PRIOR TO SLIDE FOR FACTOR OF SAFETY
OF 1.0
FOUNDATION ANALYSIS
TAN φ
0.40
0.30
0.20
0.10
0.0
2250
2200
2150
2100
2050
2000
1950
REQUIRED SHEARING STRENGTH PRIOR TO SLIDE F.S.=1.0
TAN φ IN CORE=0.30
QUICK
FIELD
0.0
0.1
0.2
0.3
0.4
0.5
COHESION - TONS PER SQ. FT.
NOTE
VALUES OF FRICTION AND COHESION DETERMINED
FROM CONSOLIDATED SHEAR TESTS ON UNDISTURBED
SAMPLES ARE INDICATED THUS:
○ WEATHERED SHALE INVOLVED IN SLIDE
✕ SURFACE CLAY
⊡ BENTONITE ⊡ BENTONITE, QUICK SHEAR
FORT PECK DAM
STABILITY ANALYSIS
UPSTREAM SLOPE AT STA. 12+75
PRIOR TO SLIDE
COMPILED BY D.R.M.
2-4-39


14+00.0
13+00.0
12+00.0
11+50.0
2350
2300
2250
2200
2150
2100
2050
2000
1950
TOP OF GROUND AFTER SLIDE
WATER
SPOIL PILE
ORIGINAL GROUND


5+00.0
8+00.0
7+00.0
6+00.0
5+00.0
4+00.0
TABLE OF WEIGHTS
SAND MATERIAL ABOVE SATURATION LINE 105 LB/CU.FT.
BELOW (BUOYED) 60
CORE MATERIAL (BUOYED) 65
DISTURBED SHALE (BUOYED) 78
WATER SURFACE EL. 2117.5
GRAVEL TOE
2112 BERM
TOP OF GROUND AFTER STRIPPING


3+00-U
2+00-U
1+00-U
AXIS
1+00-D
2+00-D
1ON 3S
22½° BERM
CORE LIMITS
SATURATION LINE
SLIDE SURFACE
TOP OF SUB-FIRM SHALE


STA 15+00
STATIC SLIDE ANALYSIS
FOUNDATION ANALYSIS
VALUES OF FRICTION AND COHESION RE-
QUIRED ALONG BASE OF DAM JUST PRIOR
TO SLIDE FOR FACTOR OF SAFETY OF 1.0
REQUIRED SHEARING STRENGTH PRIOR TO SLIDE
CORE Φ = 0.3, C = 1.0
TAN Φ
COHESION - TONS PER SQ FT
NOTE:
VALUES OF FRICTION AND COHESION DETERMINED
FROM CONSOLIDATED SHEAR TESTS ON UNDIS-
ED SAMPLES ARE INDICATED THUS:
WEATHERED SHALE INVOLVED IN SLIDE
SURFACE CLAY
BENTONITE
BENTONITE, QUICK SHEAR
FORT PECK DAM
STABILITY ANALYSIS
UPSTREAM SLOPE AT STA. 15+00
PRIOR TO SLIDE
COMPILED BY DIR M.
E. - A. - 59



(Face p. 14) No. 18

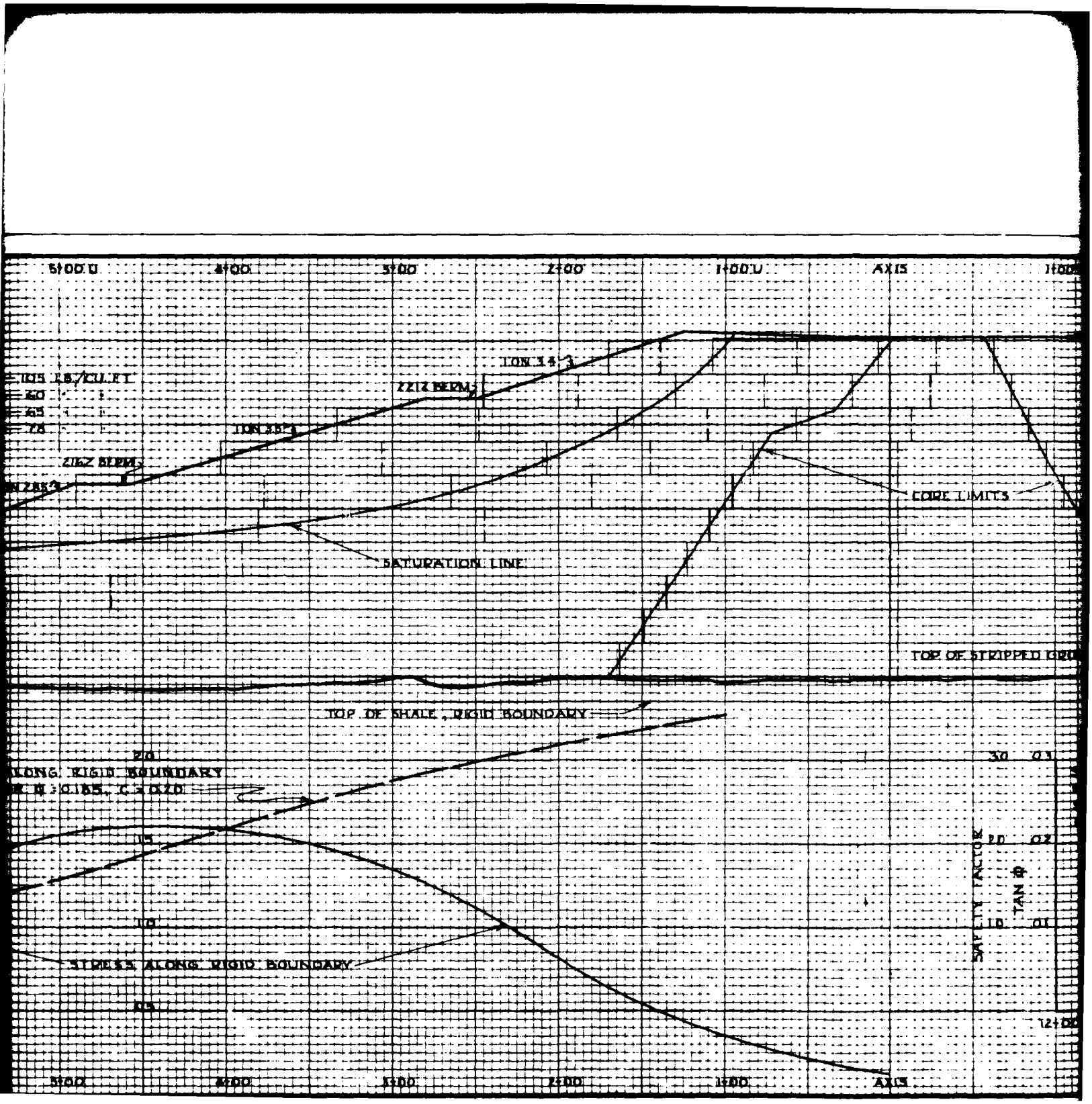
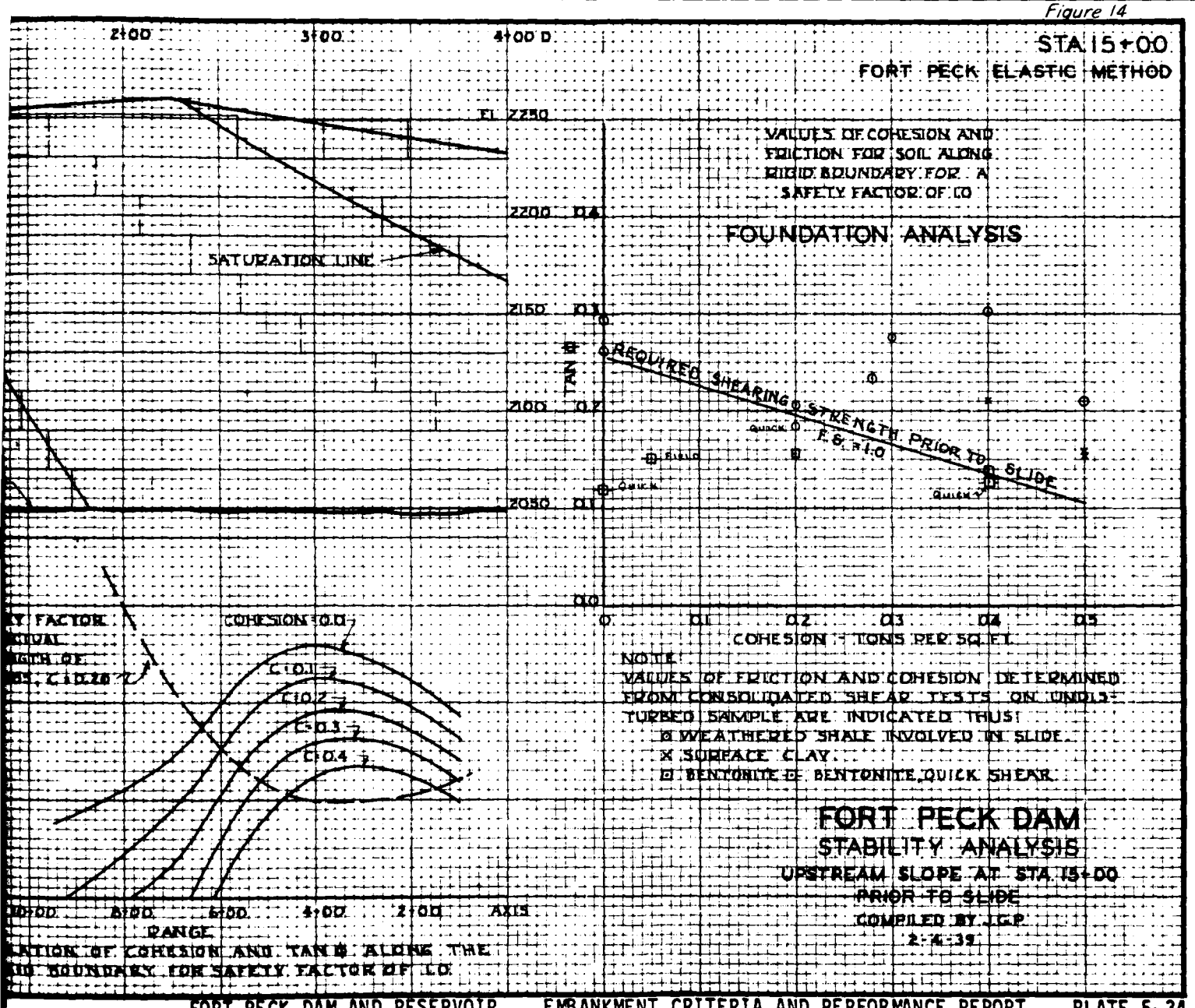
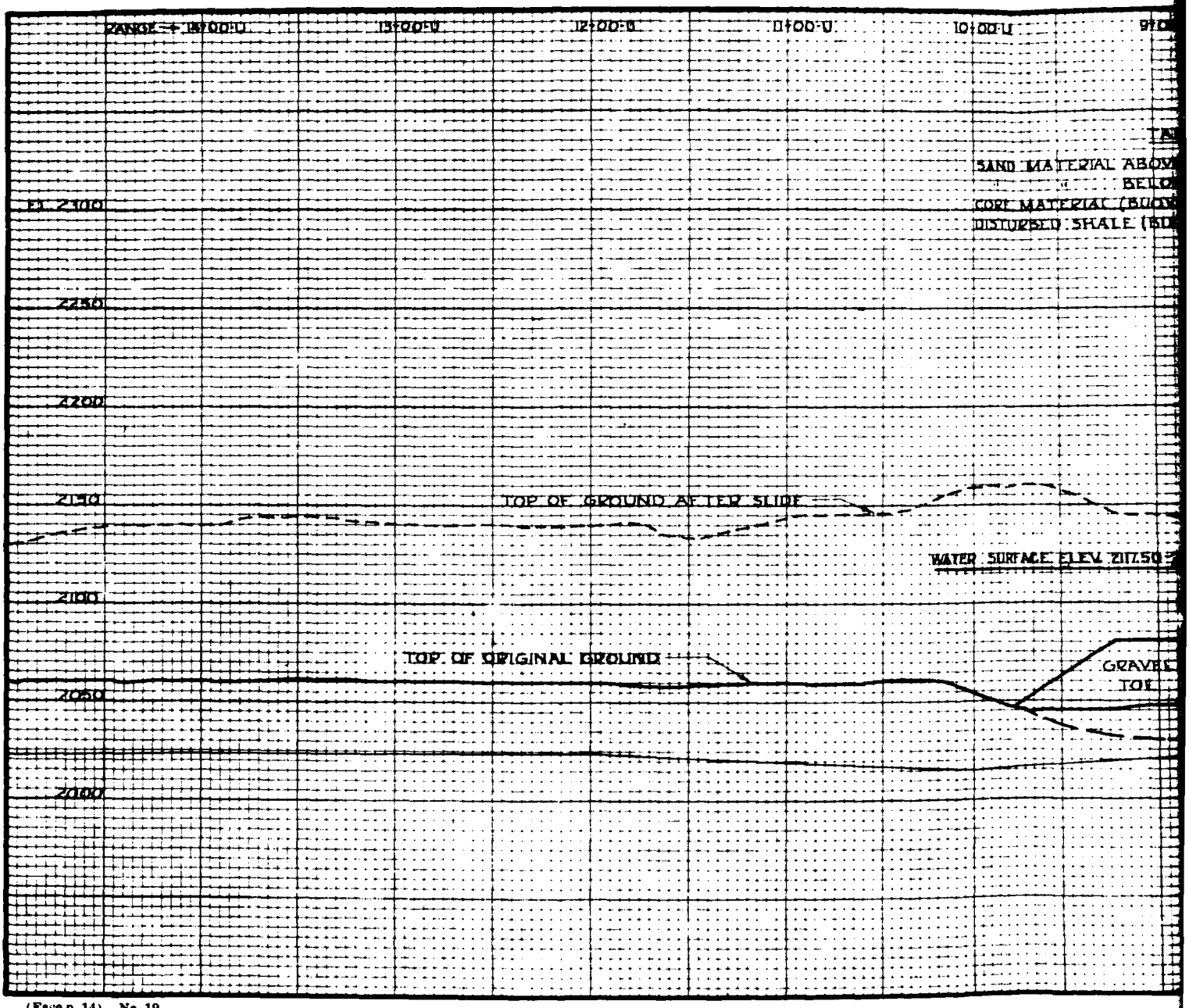

5+00.0
4+00
3+00
2+00
1+00.0
AXIS
1+00
105 LB./CU.FT.
60
65
70
TON 3.4
2212 BERM
TON 2.8
2162 BERM
SATURATION LINE
CORE LIMITS
TOP OF STRIPPED ZONE
TOP OF SHALE, RIGID BOUNDARY
ALONG RIGID BOUNDARY
C = 0.020
STRESS ALONG RIGID BOUNDARY
SAFETY FACTOR
TAN Φ
12+00

Figure 14

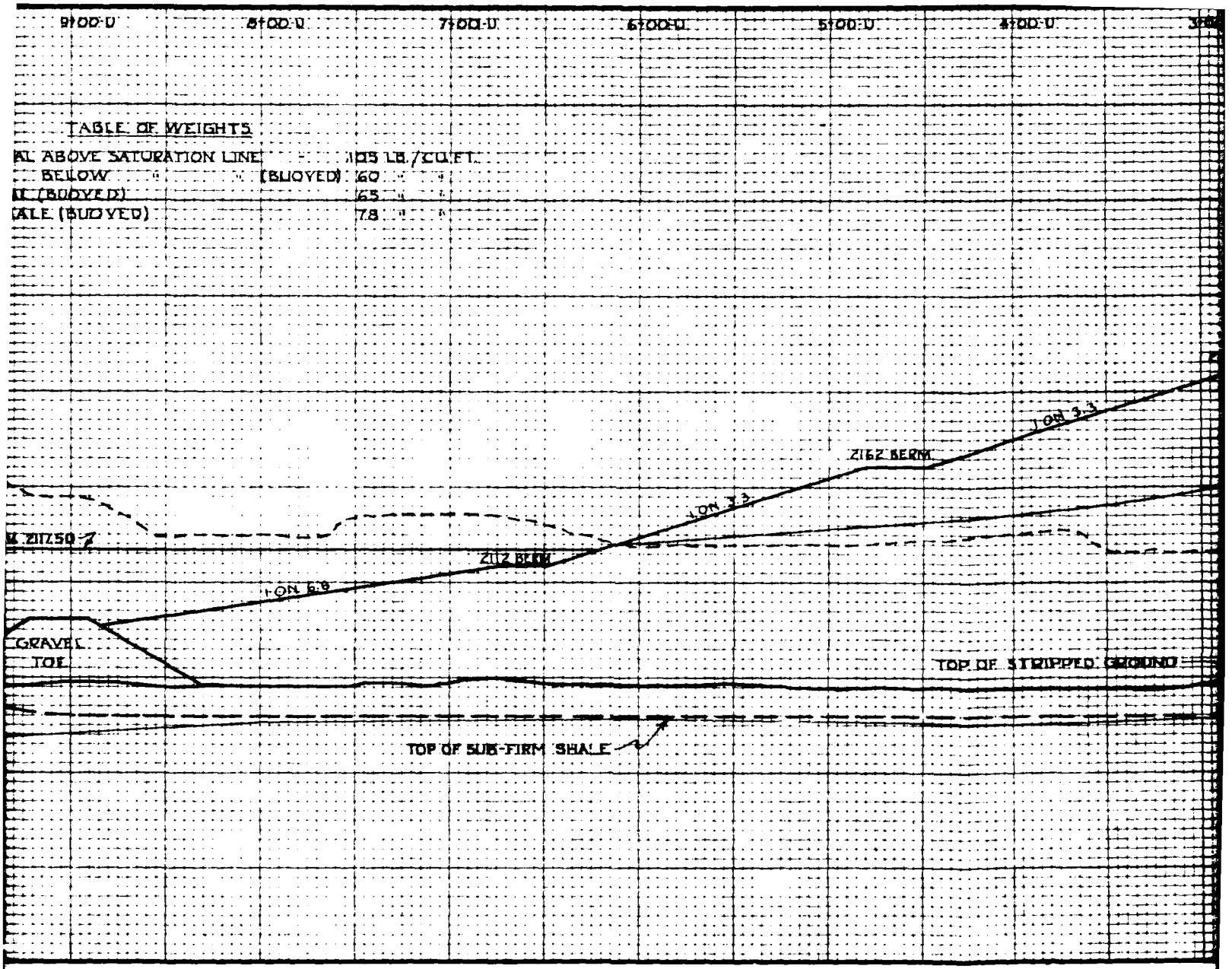


FORT PECK DAM AND RESERVOIR EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 5-34

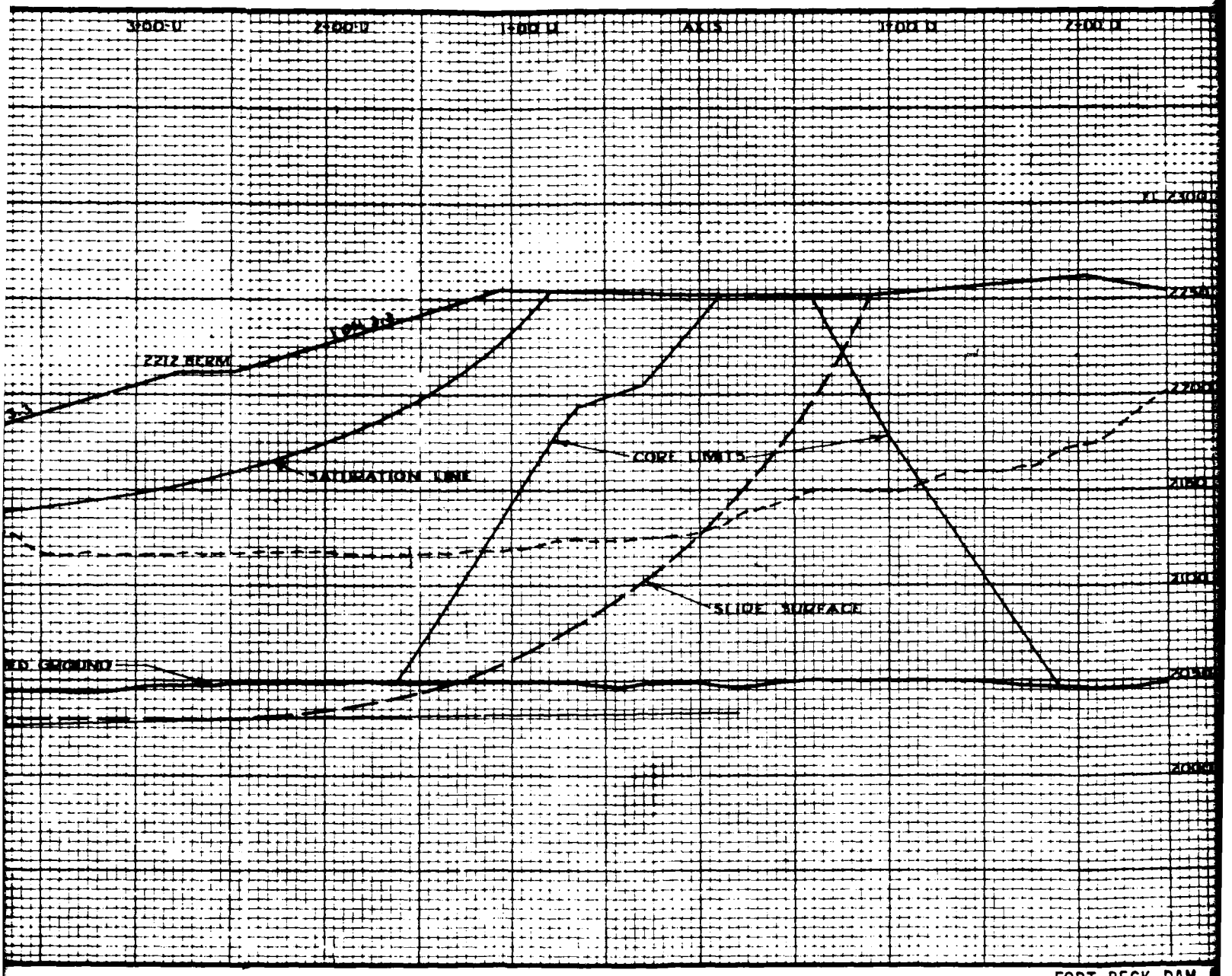
3



(Face p. 14) No. 19

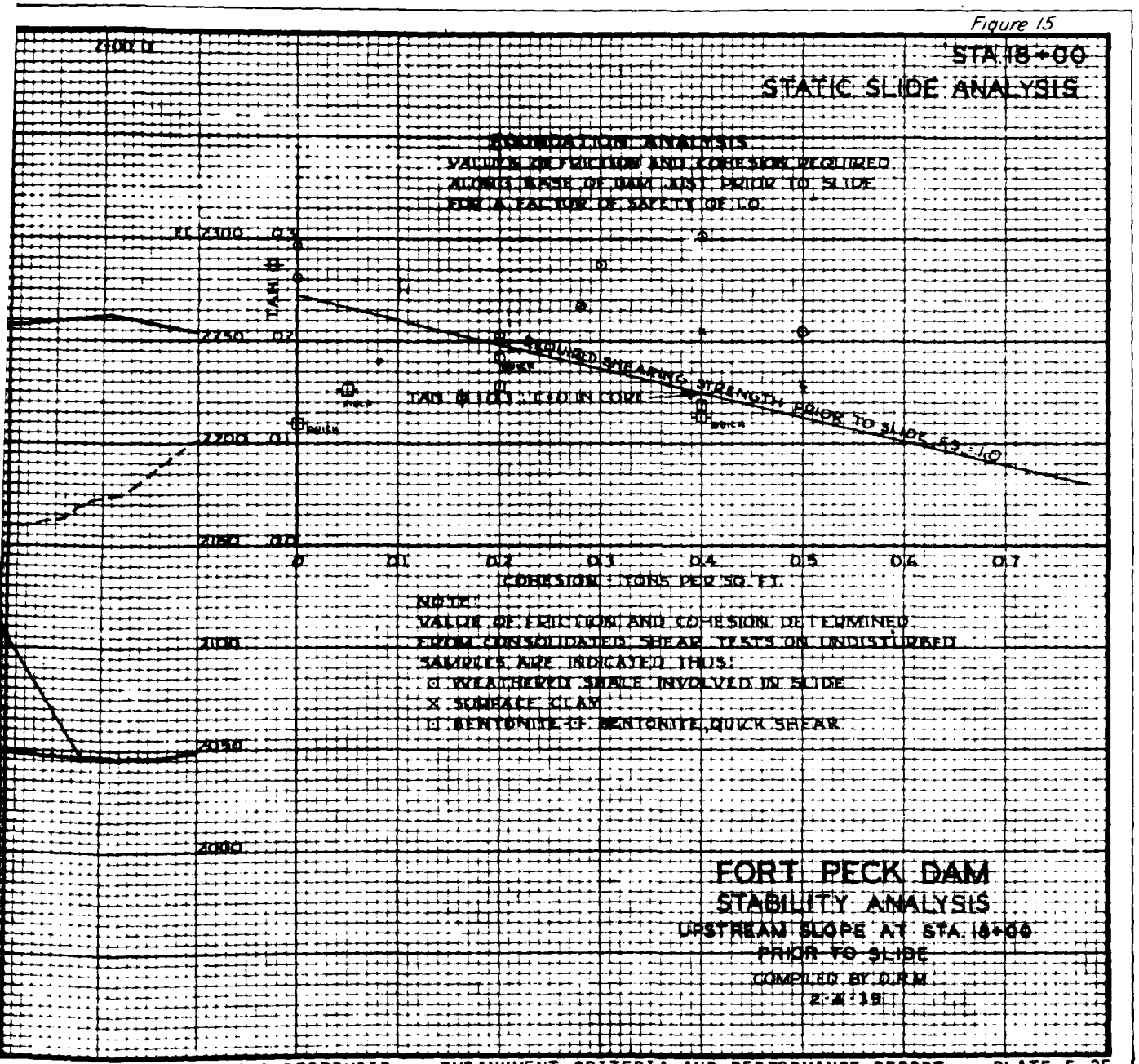

9+00.0
8+00.0
7+00.0
6+00.0
5+00.0
4+00.0
TABLE OF WEIGHTS
AL ABOVE SATURATION LINE 105 LB./CU.FT.
BELOW " (BUOYED) 60 "
L (BUOYED) 65 "
ALE (BUOYED) 78 "
1 ON 3.3
216.2' BERM
1 ON 3.3
EL 211.50
211.2' BERM
1 ON 5.9
GRAVEL
TOE
TOP OF STRIPPED GROUND
TOP OF SUB-FIRM SHALE

2

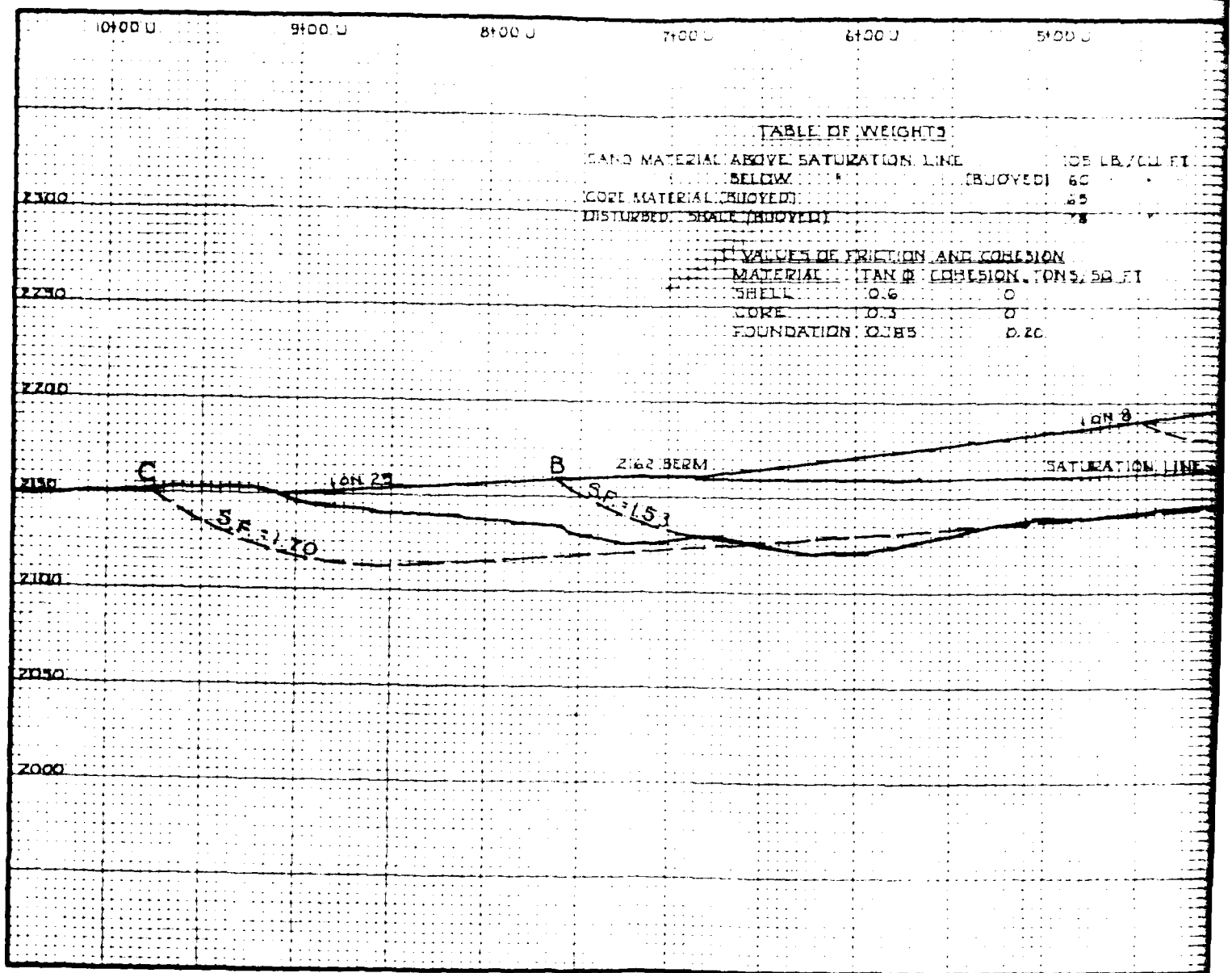


FORT PECK DAM

Figure 15

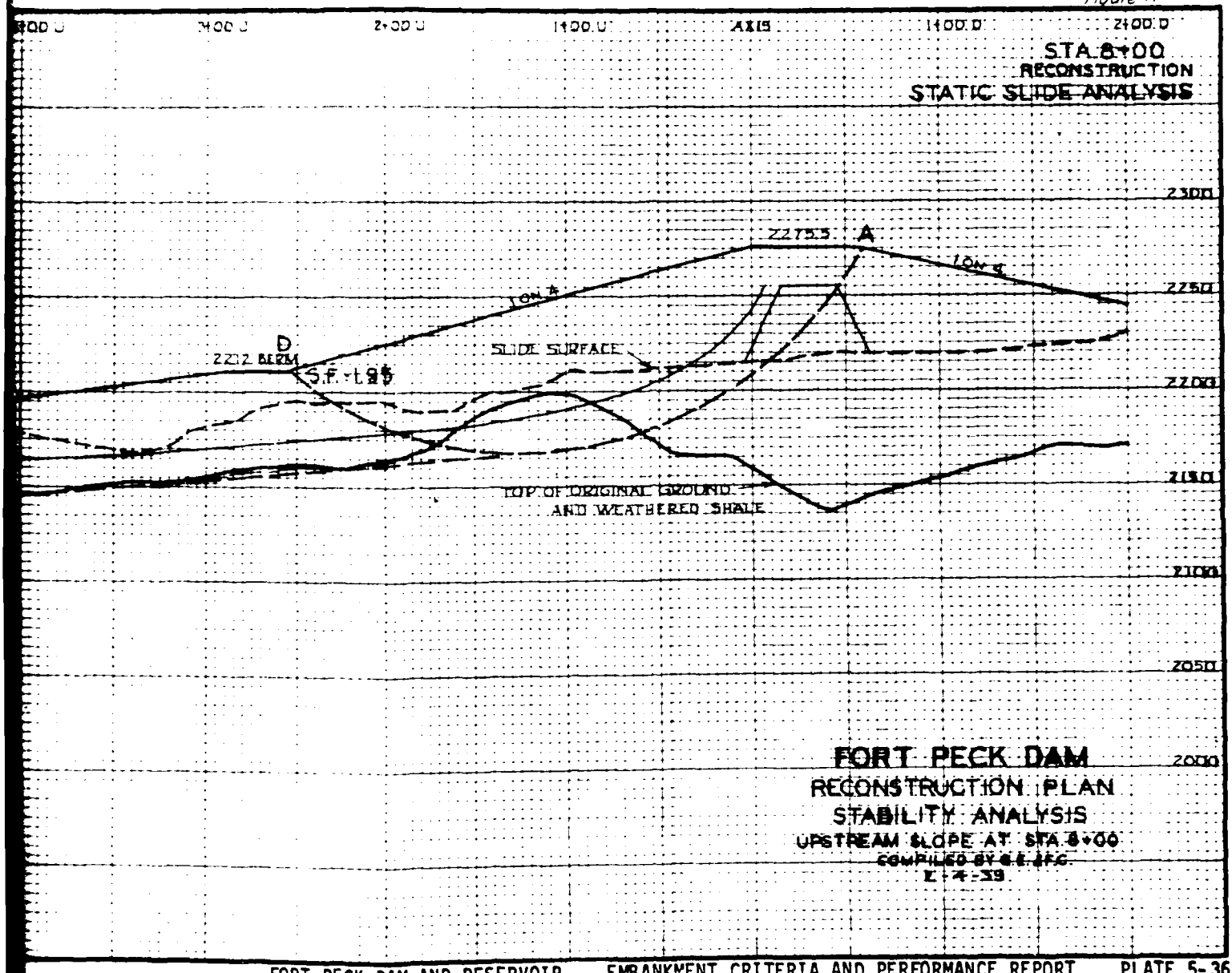

STA 18+00
STATIC SLIDE ANALYSIS
FOUNDATION ANALYSIS
VALUES OF FRICTION AND COHESION REQUIRED
ALONG BASE OF DAM JUST PRIOR TO SLIDE
FOR A FACTOR OF SAFETY OF 1.0
EL 2300
2250
2200
2150
2100
2050
2000
TAN φ
0.3
0.2
0.1
0.0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
COHESION : TONS PER SQ. FT.
REQUIRED SHEARING STRENGTH PRIOR TO SLIDE, FS = 1.0
TAN φ 10.3 ; C 1.0 IN CORE
NOTE:
VALUE OF FRICTION AND COHESION DETERMINED
FROM CONSOLIDATED SHEAR TESTS ON UNDISTURBED
SAMPLES ARE INDICATED THUS:
○ WEATHERED SHALE INVOLVED IN SLIDE
✕ SURFACE CLAY
□ BENTONITE ◇ BENTONITE, QUICK SHEAR
FORT PECK DAM
STABILITY ANALYSIS
UPSTREAM SLOPE AT STA. 18+00
PRIOR TO SLIDE
COMPILED BY D.R.M.
2-24-38

4


10+00 U
9+00 U
8+00 U
7+00 U
6+00 U
5+00 U
TABLE OF WEIGHTS
SAND MATERIAL ABOVE SATURATION LINE 105 LB./CU. FT.
BELOW " (BUOYED) 60
CORE MATERIAL (BUOYED) 65
DISTURBED SHALE (BUOYED) 78
VALUES OF FRICTION AND COHESION
MATERIAL TAN Φ COHESION, TONS/SQ. FT.
SHELL 0.6 0
CORE 0.3 0
FOUNDATION 0.385 0.20
2300
2250
2200
2150
2100
2050
2000
C
1 ON 2.5
B
216.2 BERM
1 ON 3
SATURATION LINE
SF = 1.70
SF = 1.53

(Face p. 16) No. 1

Figure 17


AXIS
STA 8+00
RECONSTRUCTION
STATIC SLIDE ANALYSIS
2300
2250
2200
2150
2100
2050
2000
2275.5
A
LOW A
LOW B
D
2272 BERM
S.F. - 1.95
SLIDE SURFACE
TOP OF ORIGINAL GROUND
AND WEATHERED SHALE
FORT PECK DAM
RECONSTRUCTION PLAN
STABILITY ANALYSIS
UPSTREAM SLOPE AT STA 8+00
COMPILED BY C.E. SFC.
E-7-39

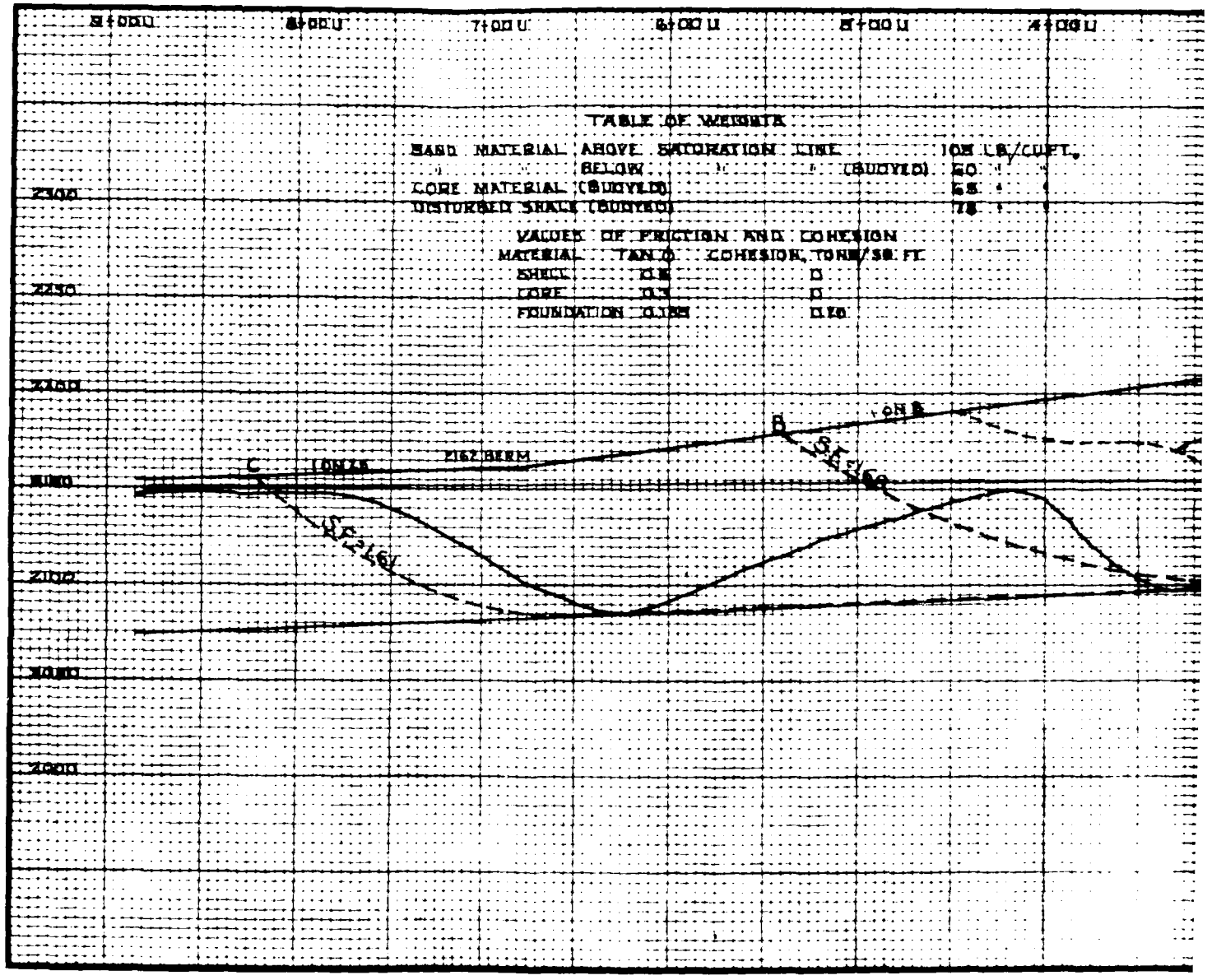
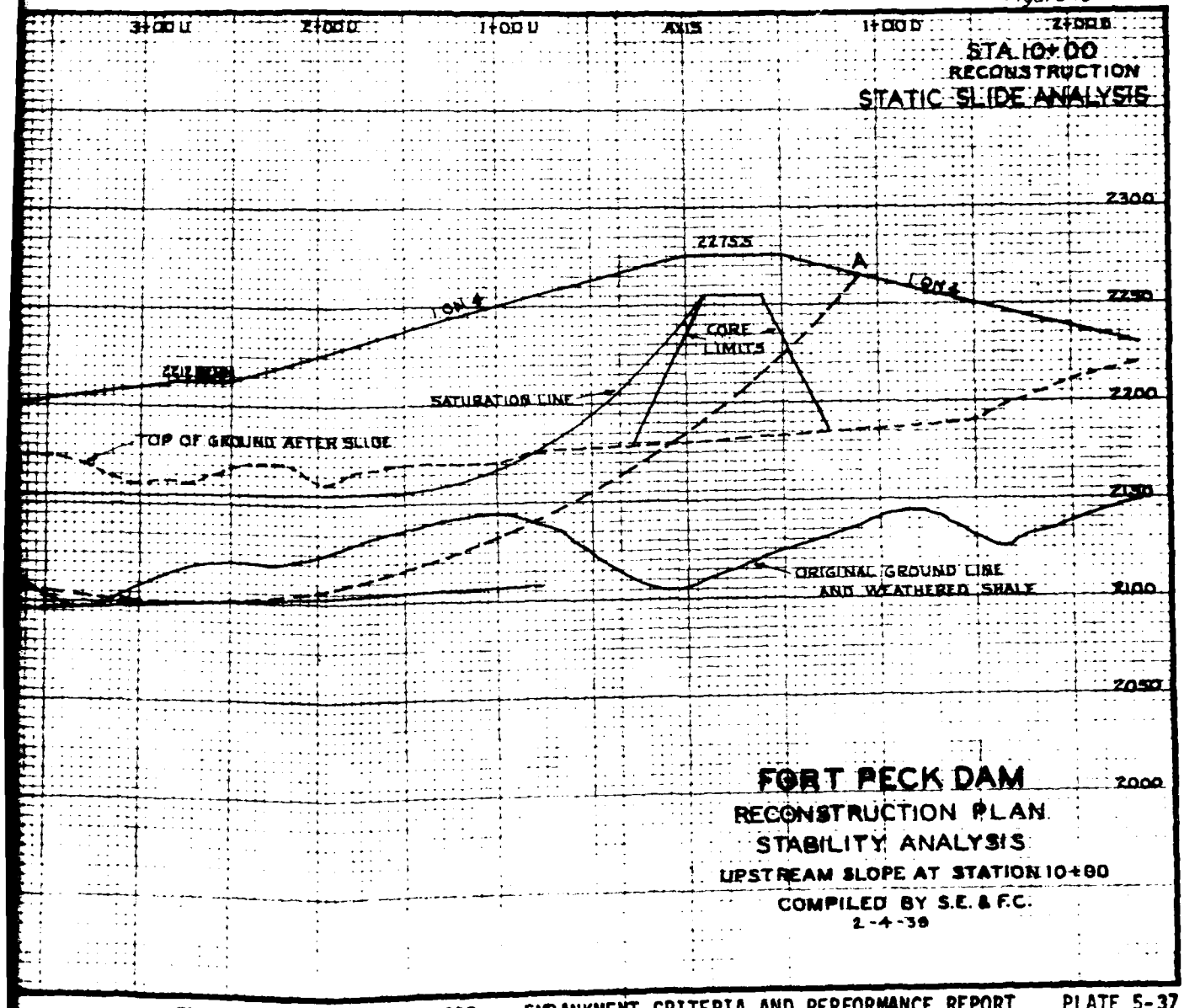


TABLE OF WEIGHTS
SAND MATERIAL ABOVE SATURATION LINE 108 LB/CUFT.
BELOW (BUOYED) 60
CORE MATERIAL (BUOYED) 65
DISTURBED SHALE (BUOYED) 78
VALUES OF FRICTION AND COHESION
MATERIAL TAN Φ COHESION, TONS/SQ. FT.
SHELL 0.8 0
CORE 0.7 0
FOUNDATION 0.364 0.50
FIRST BERM
B
C

(Face p. 16) No. 2

Figure 18



FORT PECK DAM AND RESERVOIR EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 5-37

G P O — 160810

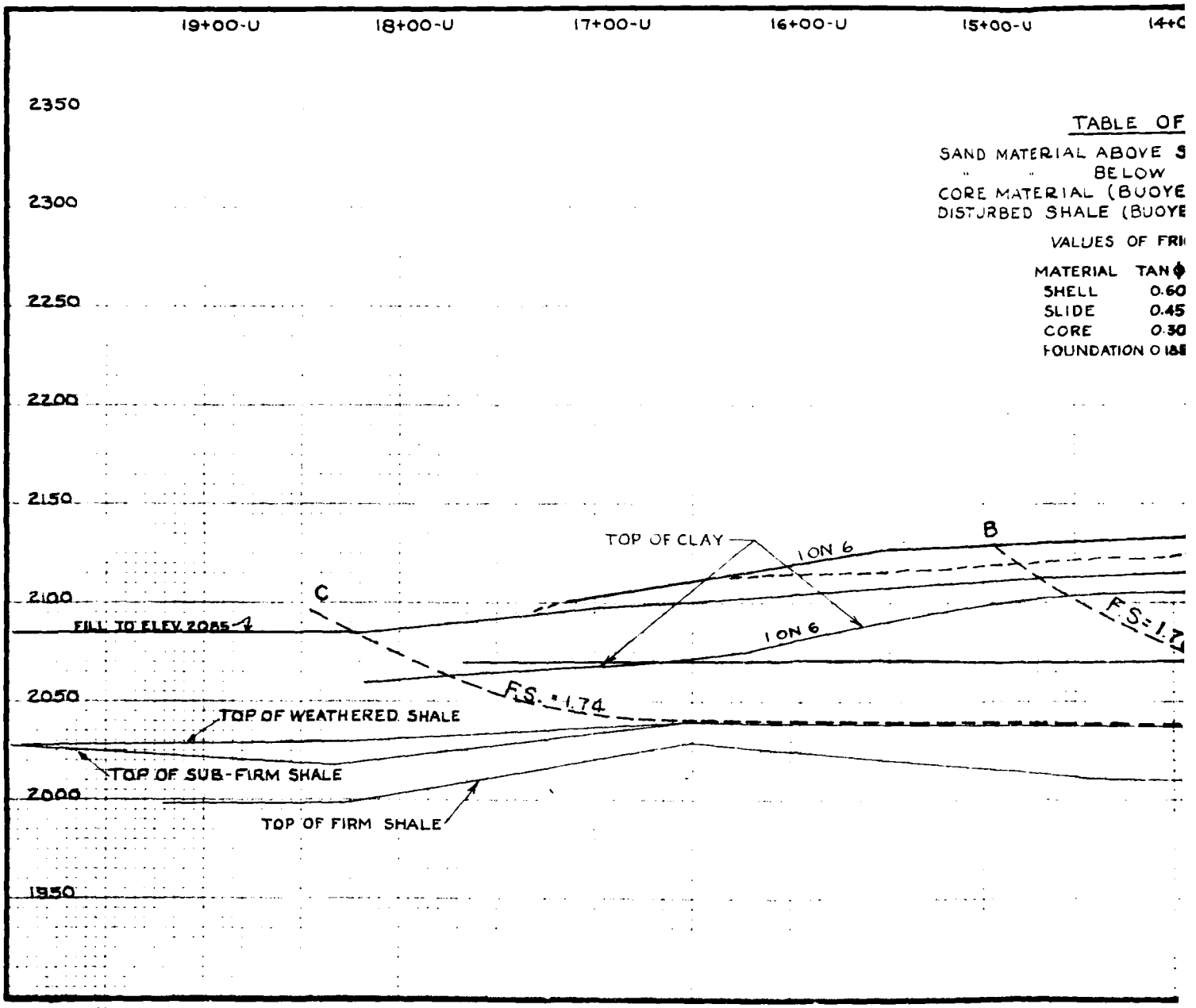


TABLE OF

SAND MATERIAL ABOVE S
" " BELOW
CORE MATERIAL (BUOYE
DISTURBED SHALE (BUOYE

VALUES OF FRI

MATERIAL	TAN ϕ
SHELL	0.60
SLIDE	0.45
CORE	0.30
FOUNDATION	0.18

(Face p. 16) No. 3

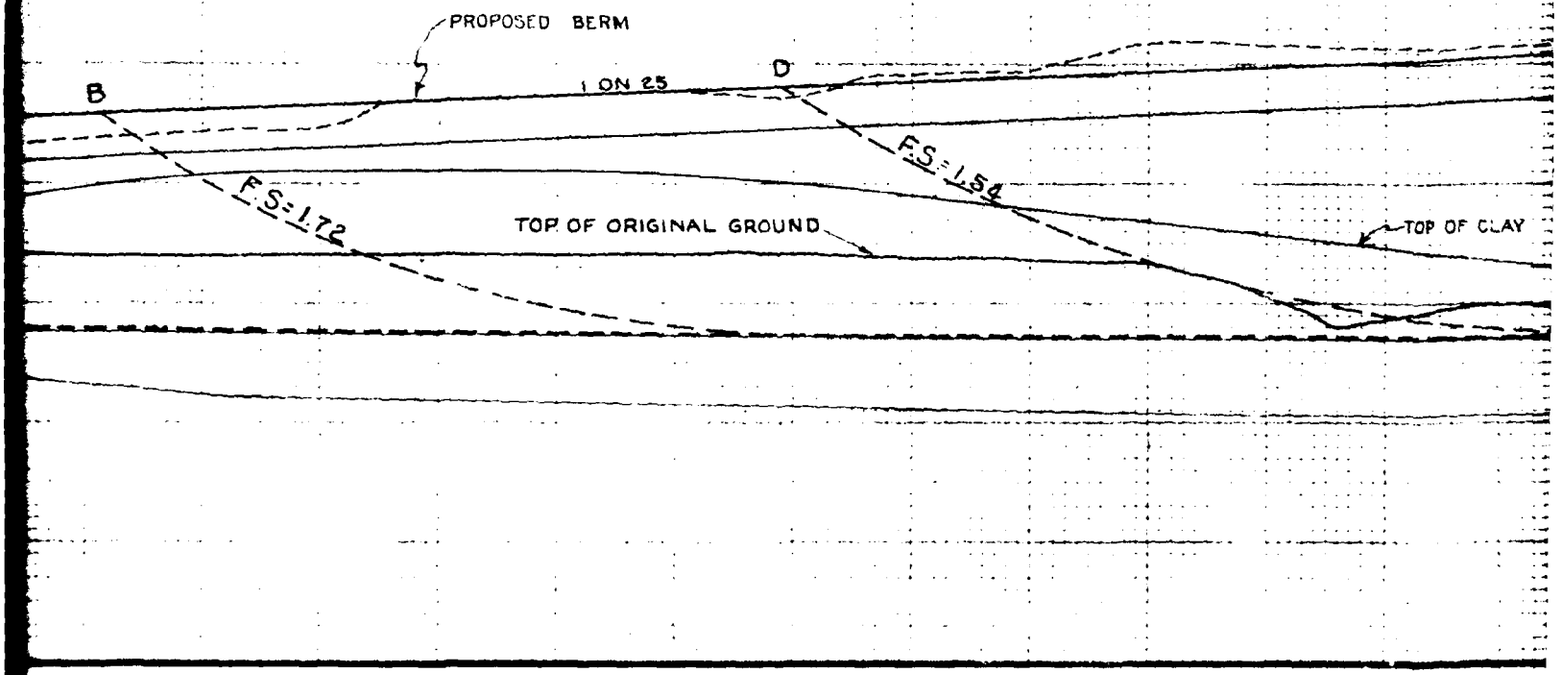
15+00-U 14+00-U 13+00-U 12+00-U 11+00-U 10+00-U 9+00-U

TABLE OF WEIGHTS

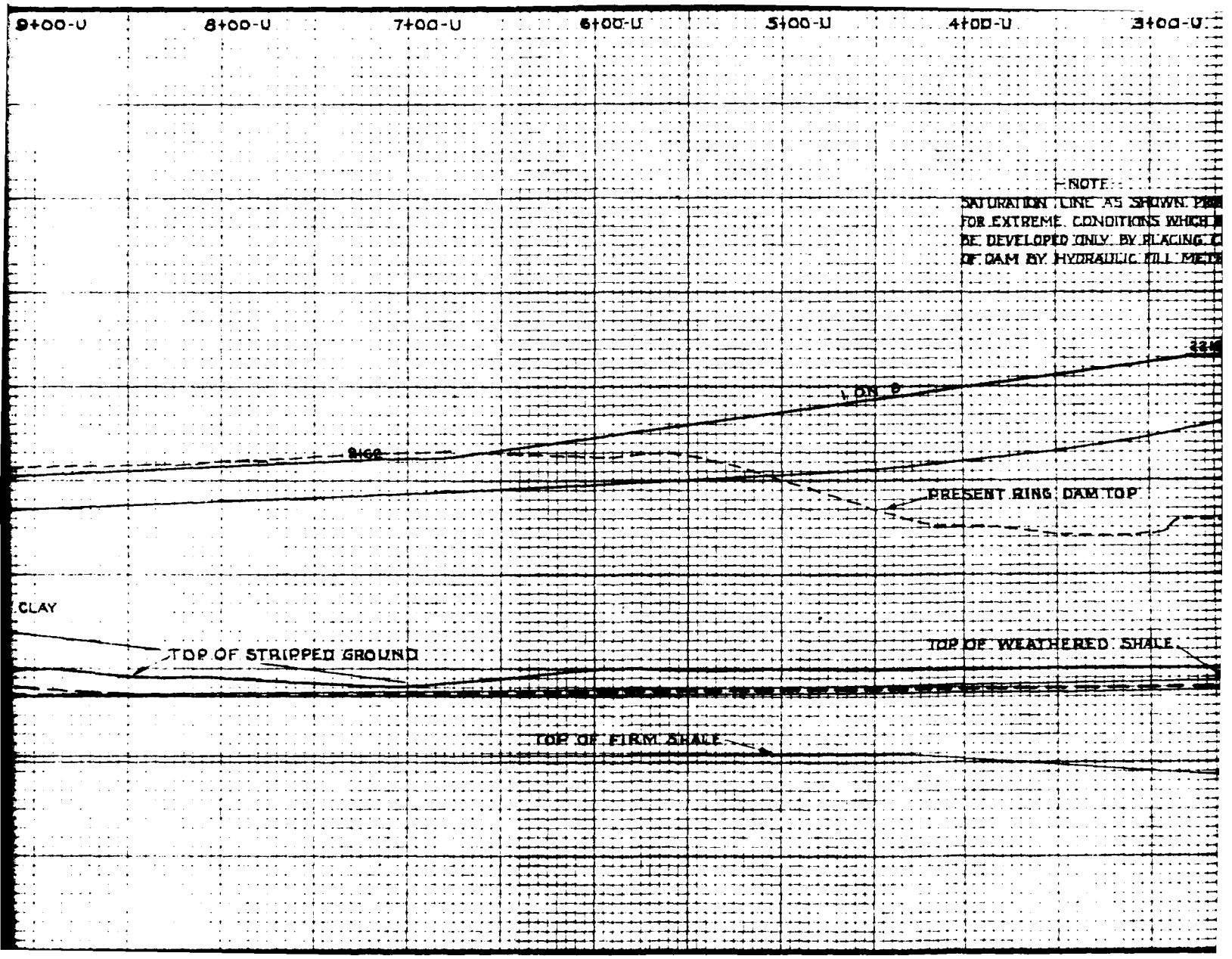
SAND MATERIAL ABOVE SATURATION LINE		105 LB./CU.FT.
" " BELOW " "	(BUOYED)	60 " "
CORE MATERIAL (BUOYED)		65 " "
DISTURBED SHALE (BUOYED)		78 " "

VALUES OF FRICTION AND COHESION

MATERIAL	TAN ϕ	COHESION TONS/SQ.FT.
SHELL	0.60	0.0
SLIDE	0.45	0.0
CORE	0.30	0.0
FOUNDATION	0.185	0.20



2


9+00-U
8+00-U
7+00-U
6+00-U
5+00-U
4+00-U
3+00-U
NOTE
SATURATION LINE AS SHOWN
FOR EXTREME CONDITIONS WHICH
BE DEVELOPED ONLY BY PLACING
OF DAM BY HYDRAULIC FILL METH
EL DAM
EL 968
PRESENT RING DAM TOP
CLAY
TOP OF STRIPPED GROUND
TOP OF WEATHERED SHALE
TOP OF FIRM SHALE

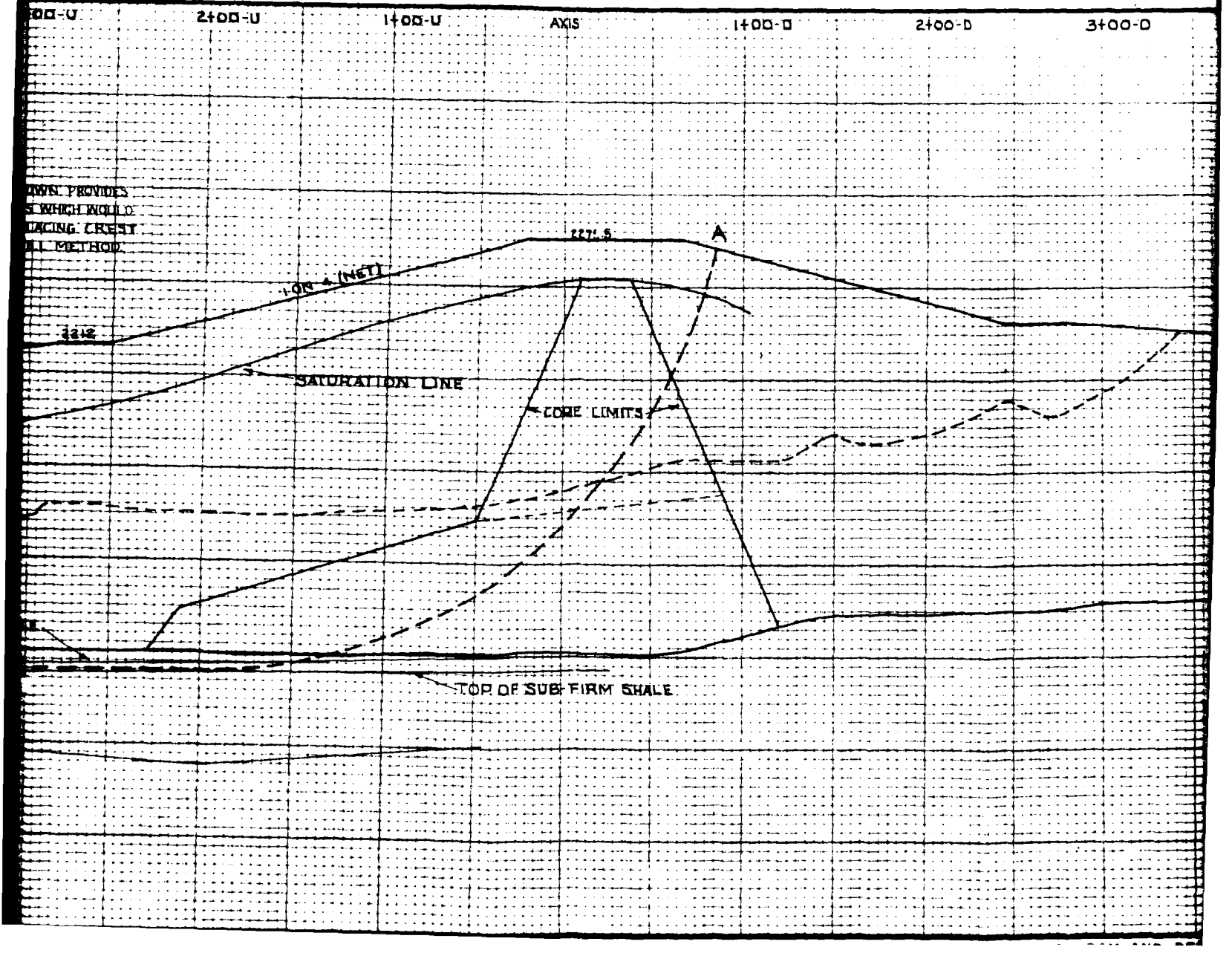
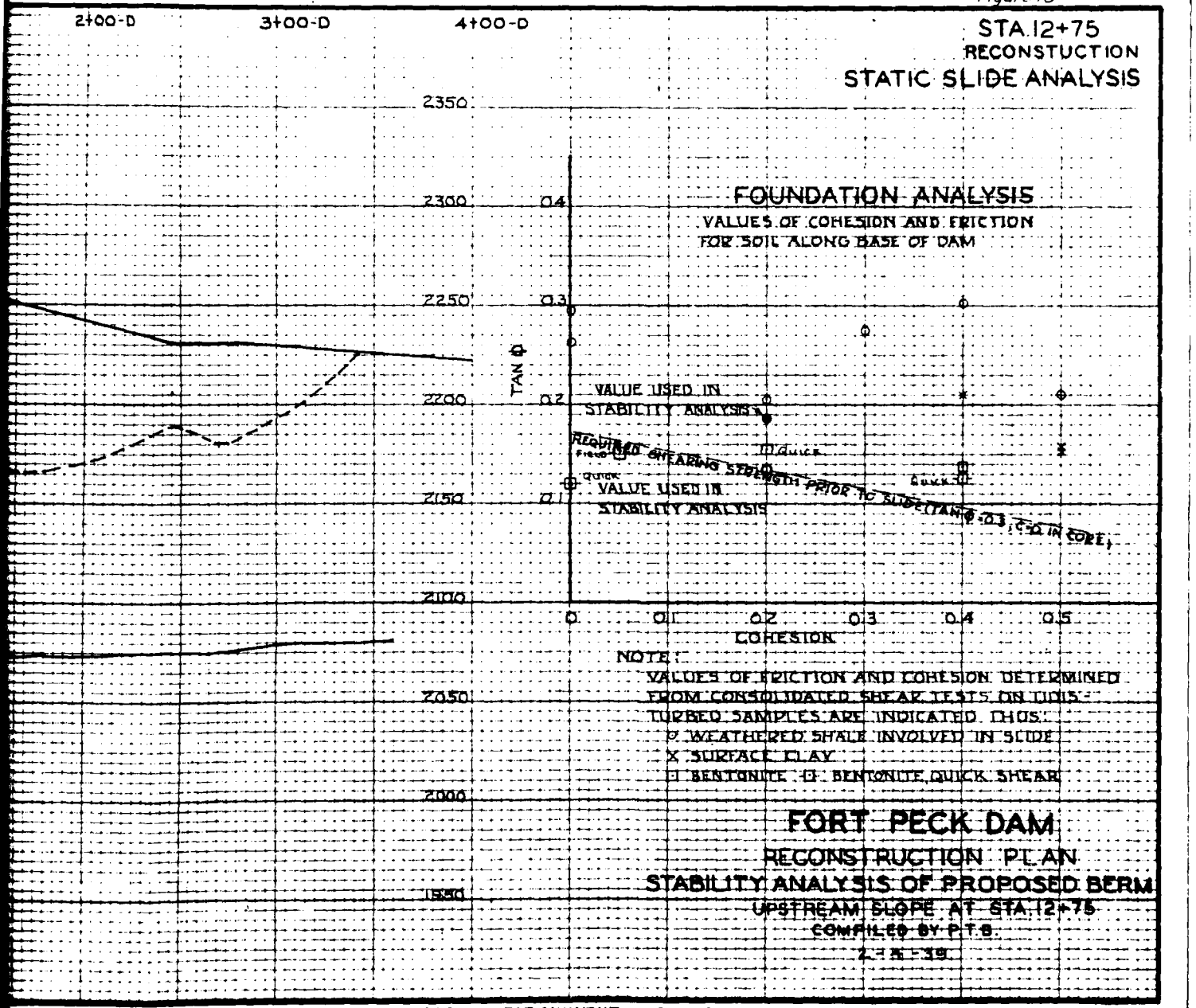
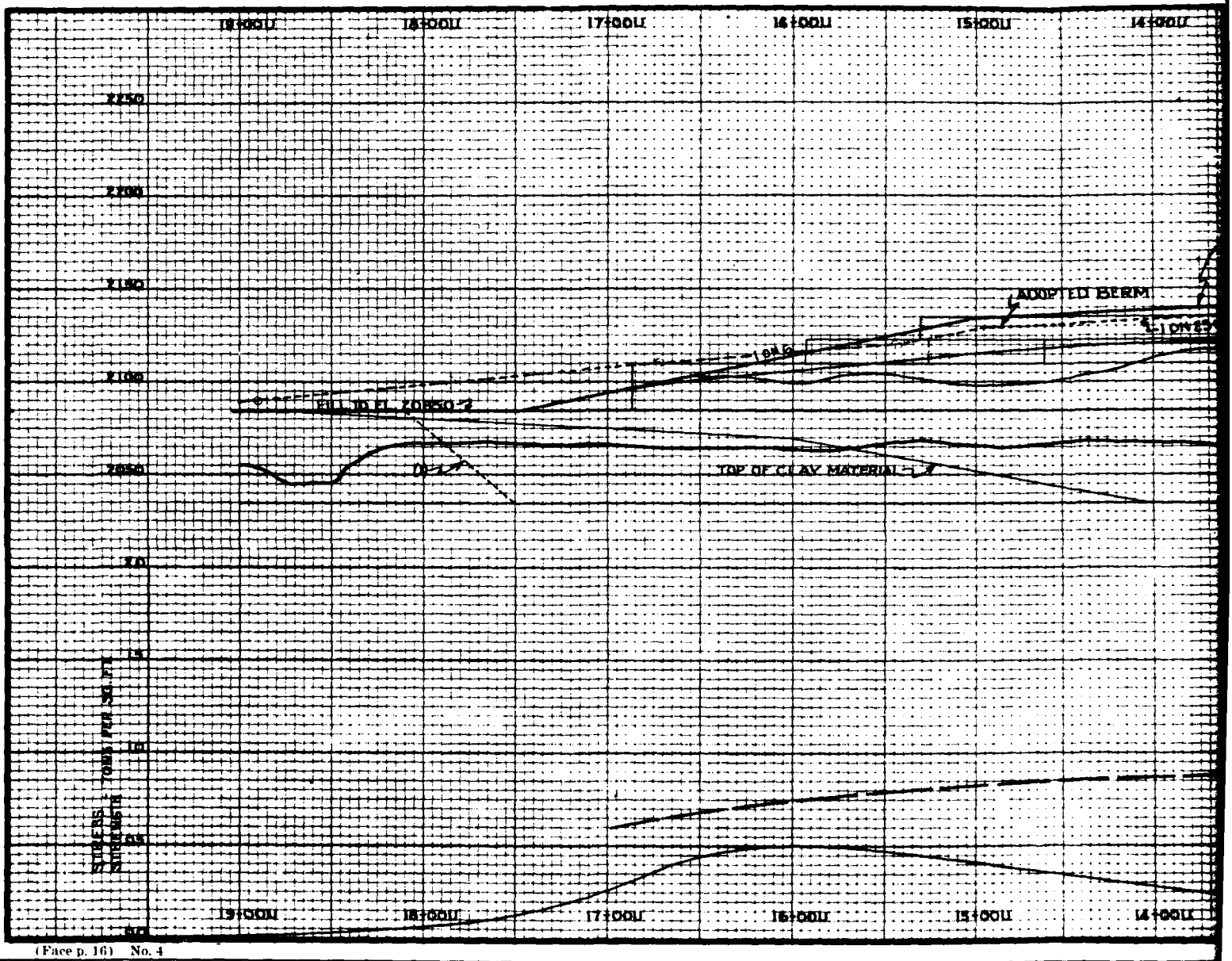

00-U
2+00-U
1+00-U
AXIS
1+00-D
2+00-D
3+00-D
WN. PROVIDES
WHICH WOULD
ACING CREST
L METHOD
227'.5
A
1 OR 4 (NET)
2212
SATURATION LINE
CORE LIMITS
TOP OF SUB-FIRM SHALE

Figure 19



FORT PECK DAM AND RESERVOIR EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 5-38

5


19+00LL
18+00LL
17+00LL
16+00LL
15+00LL
14+00LL
ADOPTED BERM
FILL TO EL. ZORSO
TOP OF CLAY MATERIAL
STRESS - TONS PER SQ. FT.

(Face p. 16) No. 4

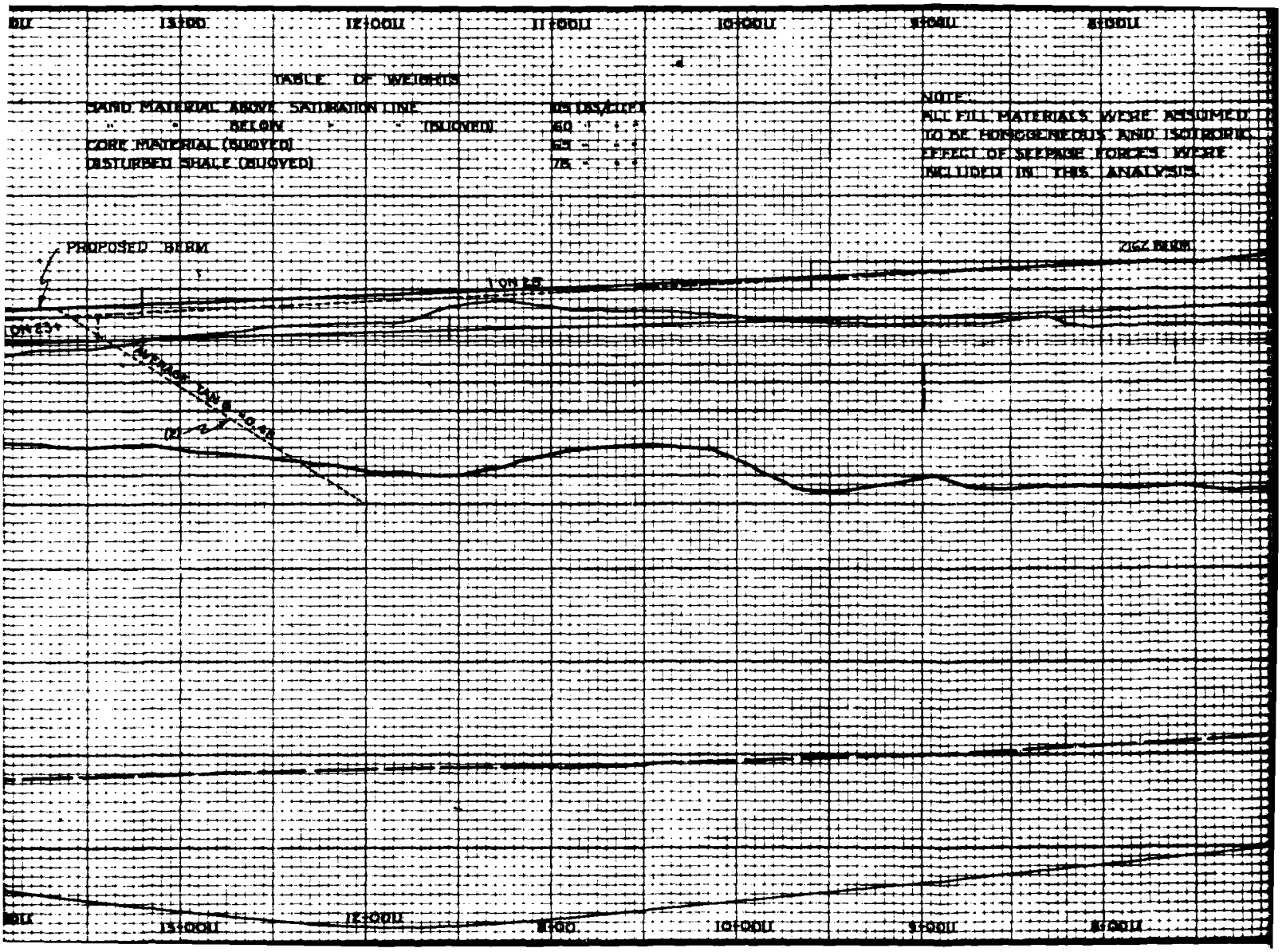
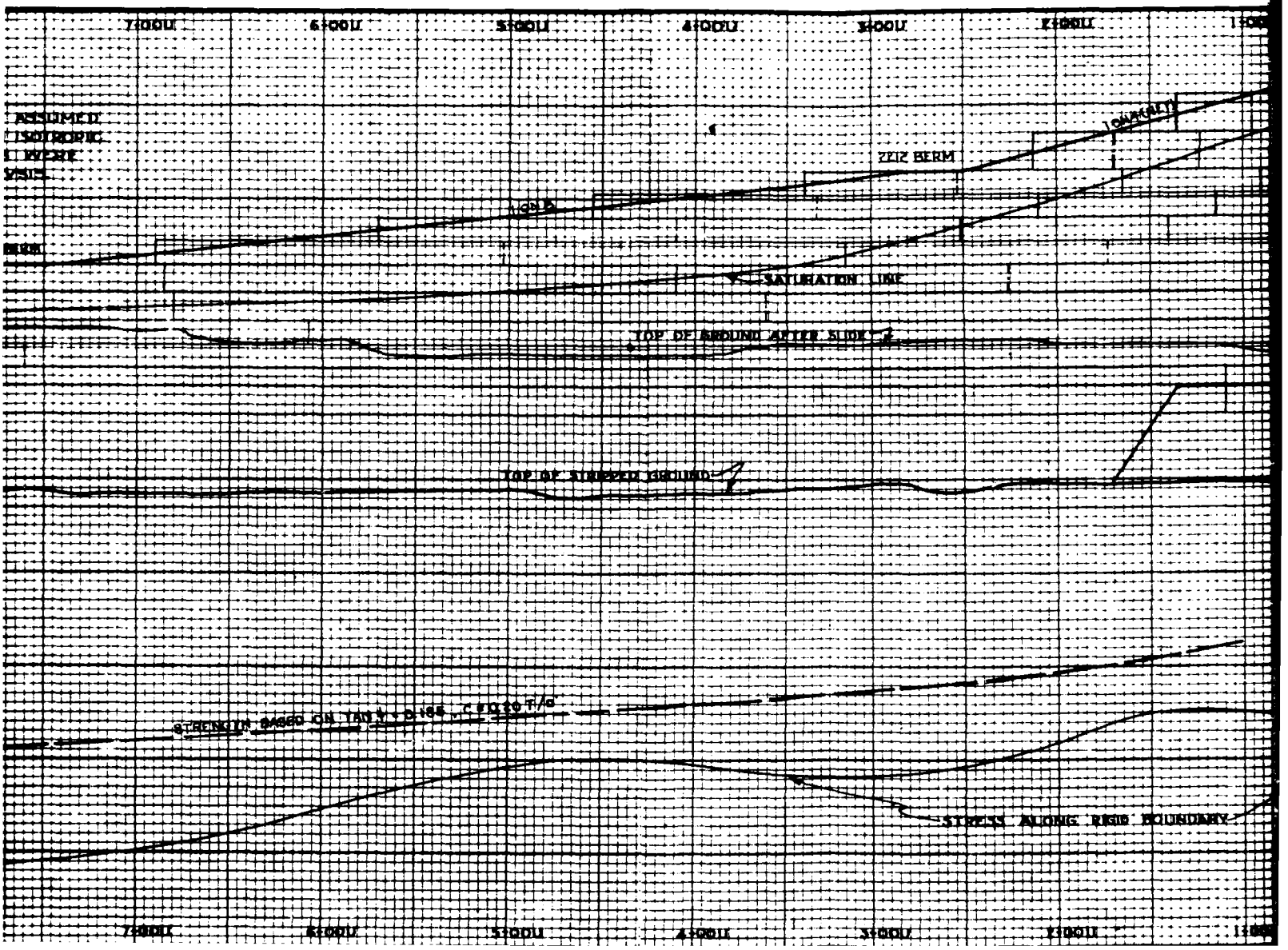


TABLE OF WEIGHTS
SAND MATERIAL ABOVE SATURATION LINE
" " BELOW " " (BUOYED)
CORE MATERIAL (BUOYED)
DISTURBED SHALE (BUOYED)
NOTE:
ALL FILL MATERIALS WERE ASSUMED TO BE HOMOGENEOUS AND ISOTROPIC. EFFECT OF SEEPAGE FORCES WERE INCLUDED IN THIS ANALYSIS.
PROPOSED BERM
ZIGZ BERM


7+00U
6+00U
5+00U
4+00U
3+00U
2+00U
1+00
ASSUMED
ISOTROPIC
I WERE
SHIS
ZEIZ BERM
SATURATION LINE
TOP OF GROUND AFTER SLIDE
TOP OF STRIPPED GROUND
STRENGTH BASED ON TAN
STRESS ALONG RIGID BOUNDARY

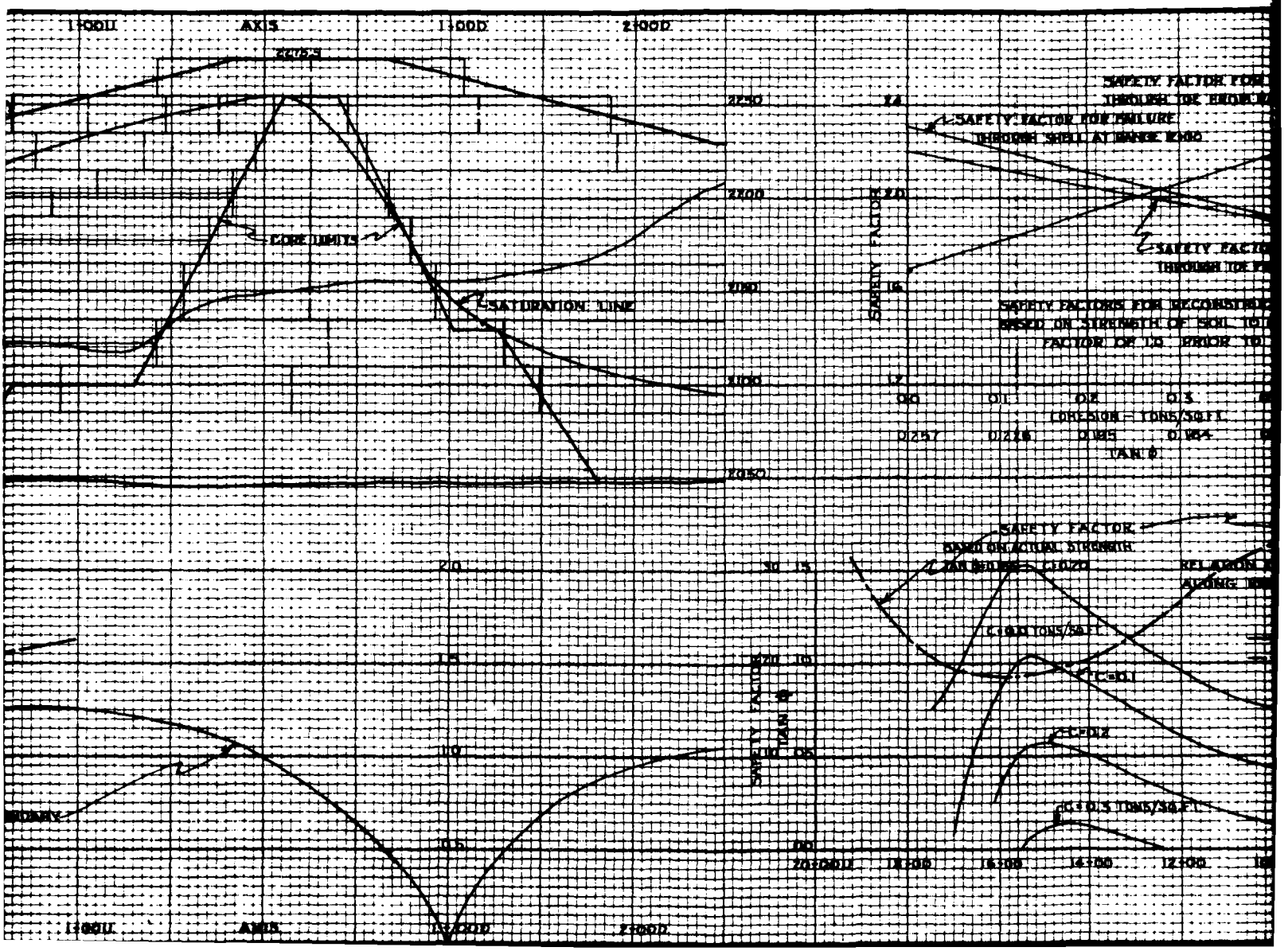
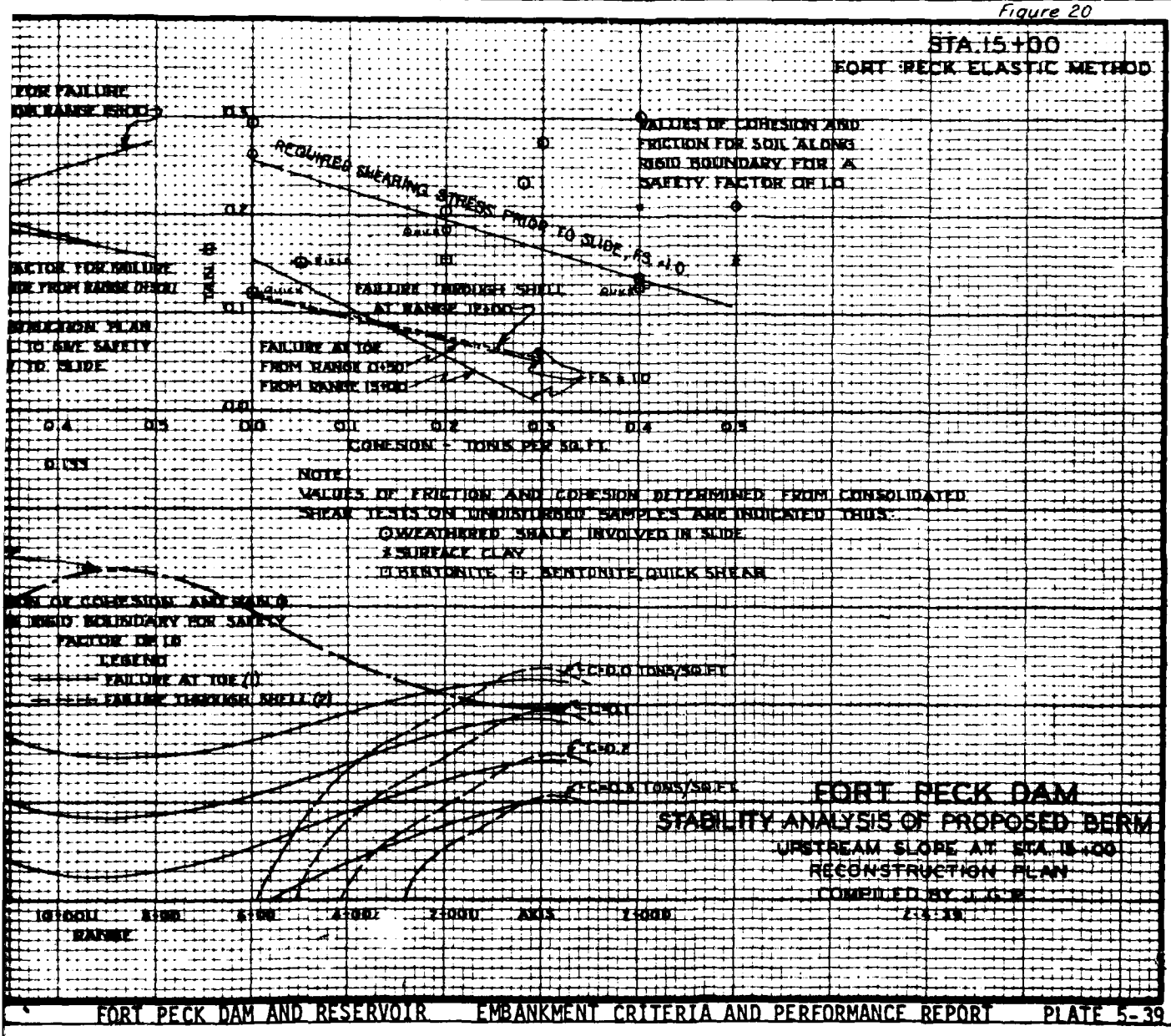
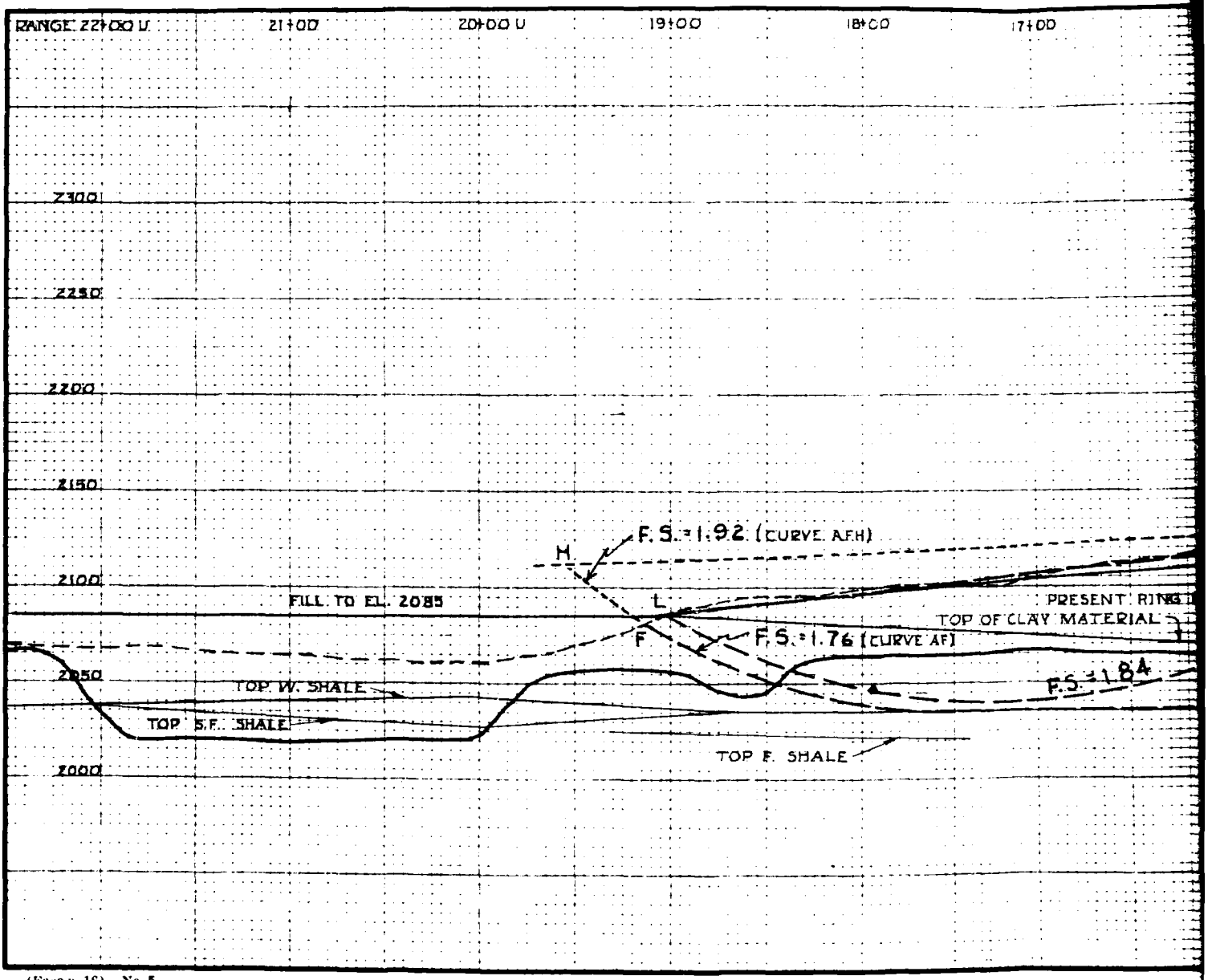
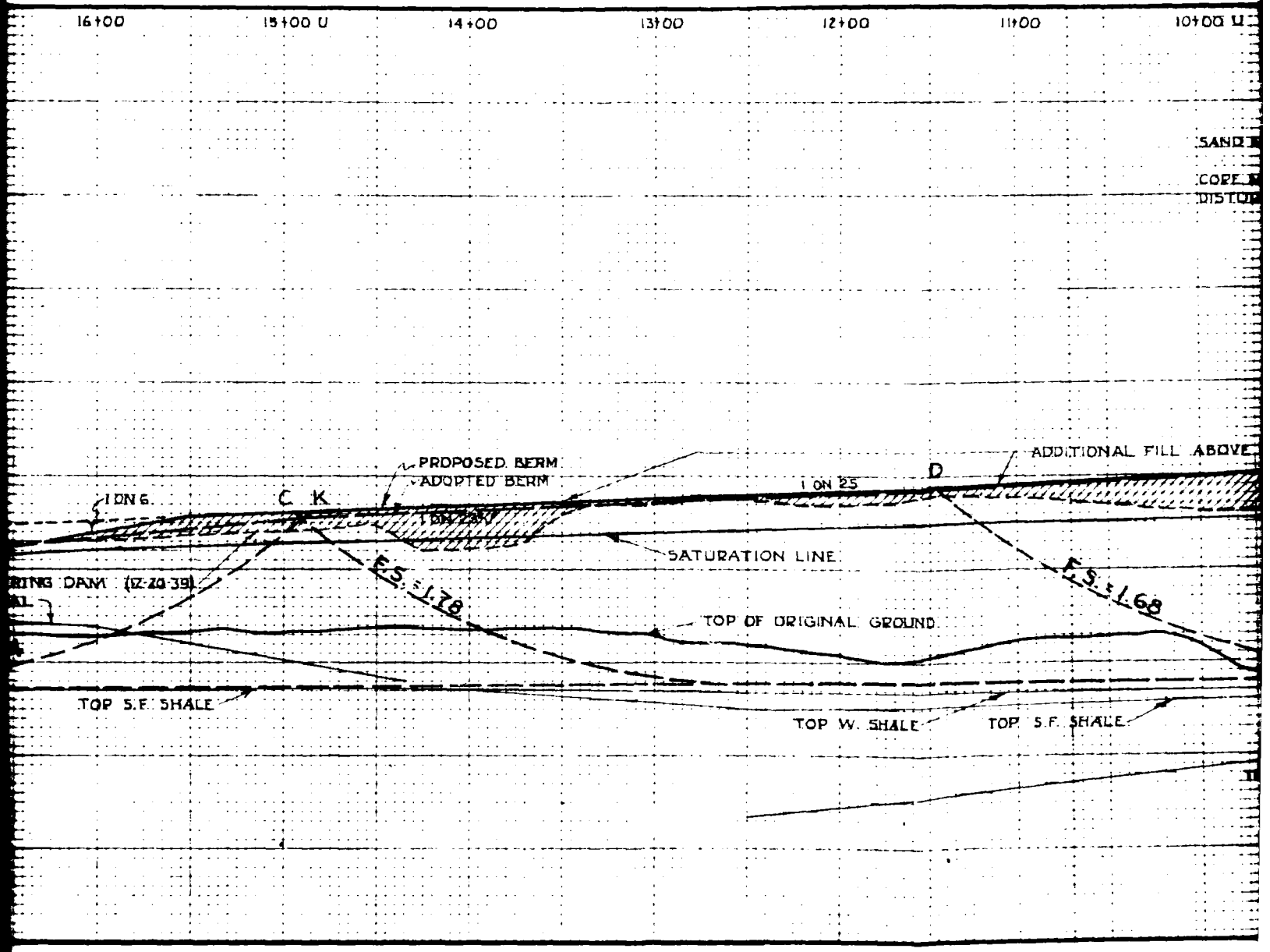

AXIS
CORE LIMITS
SATURATION LINE
SAFETY FACTOR FOR FAILURE
THROUGH SHELL AT BASE ROCK
SAFETY FACTORS FOR RECONSTRUCTED
BASED ON STRENGTH OF SOIL TO
FACTOR OF 1.0 PRIOR TO
COHESION - TONS/SQ.FT.
TAN Φ
SAFETY FACTOR
BASED ON ACTUAL STRENGTH
TAN Φ
C=0.2 TONS/SQ.FT.
C=0.1
C=0.2
C=0.3 TONS/SQ.FT.
SAFETY FACTOR
RELATION
ASSUMING

Figure 20

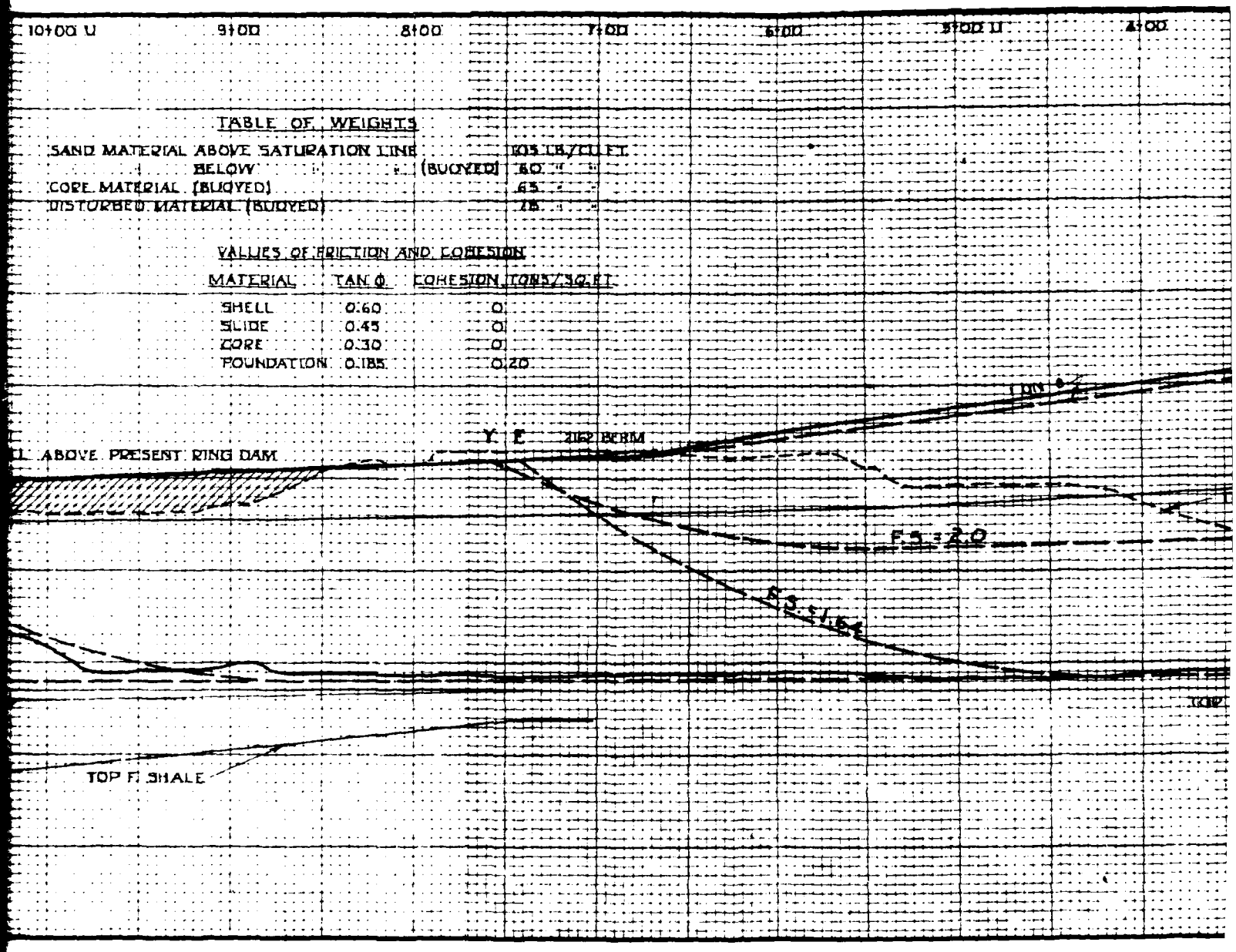

STA. 15+00
FORT PECK ELASTIC METHOD
VALUES OF COHESION AND FRICTION FOR SOIL ALONG RIGID BOUNDARY FOR A SAFETY FACTOR OF 1.0
REQUIRED SHEARING STRESS PRIOR TO SLIDE, Fs = 1.0
FAILURE THROUGH SHELL AT RANGE 12+00
FAILURE AT TOE FROM RANGE 0+50
FROM RANGE 15+00
F.S. = 1.00
COHESION - TONS PER SQ. FT.
NOTE
VALUES OF FRICTION AND COHESION DETERMINED FROM CONSOLIDATED SHEAR TESTS ON UNDISTURBED SAMPLES ARE INDICATED THUS:
O WEATHERED SHALE INVOLVED IN SLIDE
X SURFACE CLAY
B BENTONITE B BENTONITE, QUICK SHEAR
FAILURE AT TOE (1)
FAILURE THROUGH SHELL (2)
C=0.0 TONS/SQ.FT.
C=0.1
C=0.2
C=0.4 TONS/SQ.FT.
FORT PECK DAM
STABILITY ANALYSIS OF PROPOSED BERM
UPSTREAM SLOPE AT STA. 15+00
RECONSTRUCTION PLAN
COMPILED BY J.G.W.
AXIS


RANGE 22+00 U
21+00
20+00 U
19+00
18+00
17+00
2300
2250
2200
2150
2100
2050
2000
F.S.=1.92 (CURVE AFH)
H
FILL TO EL. 2085
L
PRESENT RING
TOP OF CLAY MATERIAL
F
F.S.=1.76 (CURVE AF)
F.S.=1.84
TOP W. SHALE
TOP S.F. SHALE
TOP F. SHALE

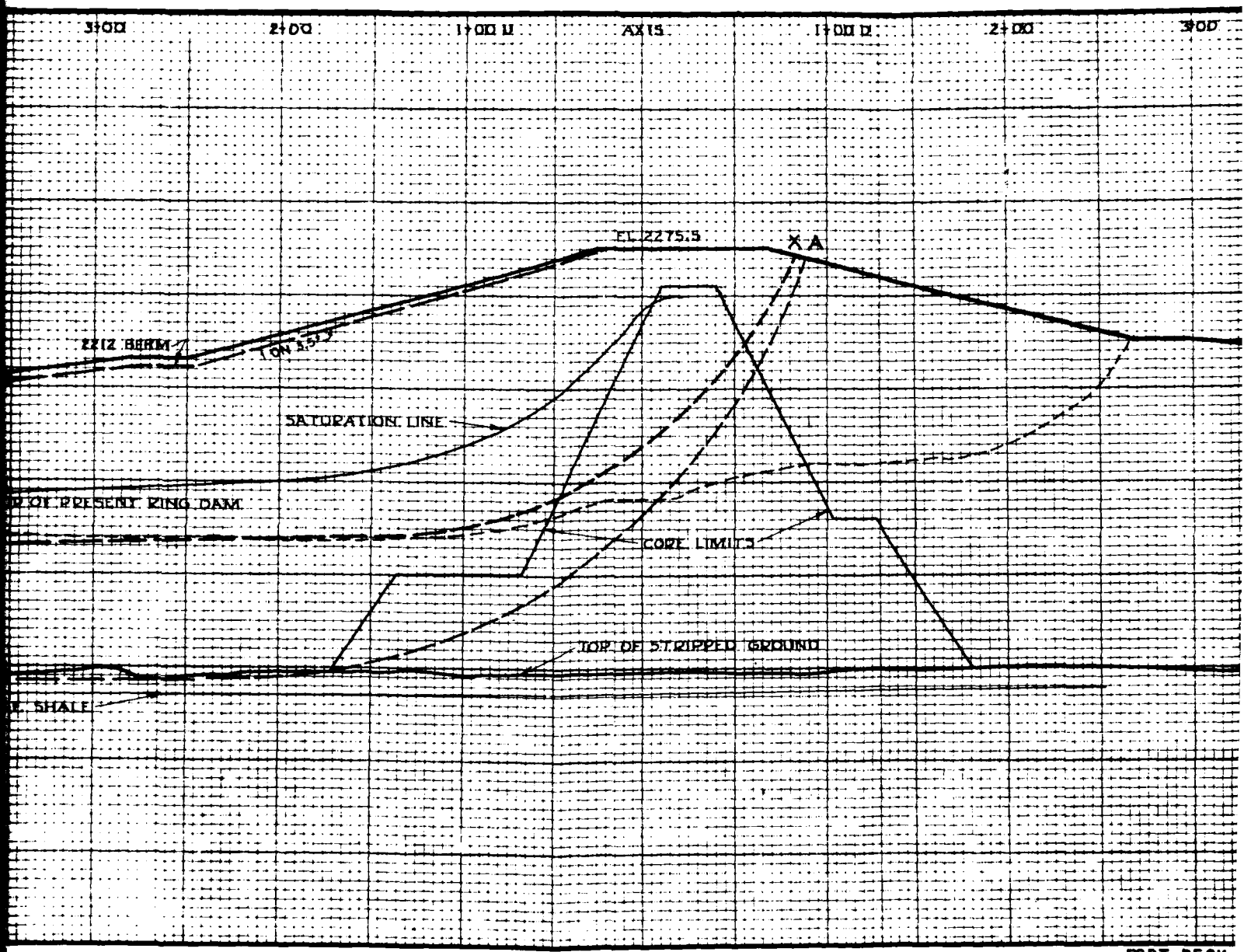
(Face p. 16) No. 5


16+00
15+00 U
14+00
13+00
12+00
11+00
10+00 U
SAND
CORE
DIST
PROPOSED BERM
ADOPTED BERM
ADDITIONAL FILL ABOVE
1 ON 6
C
K
1 ON 25
D
SATURATION LINE
F.S. = 1.78
F.S. = 1.68
TOP OF ORIGINAL GROUND
TOP S.F. SHALE
TOP W. SHALE
TOP S.F. SHALE

2


10+00 U
9+00
8+00
7+00
6+00
5+00 U
4+00
TABLE OF WEIGHTS
SAND MATERIAL ABOVE SATURATION LINE 105 LB/CU.FT.
BELOW (BUOYED) 60 "
CORE MATERIAL (BUOYED) 65 "
DISTURBED MATERIAL (BUOYED) 75 "
VALUES OF FRICTION AND COHESION
MATERIAL TAN φ COHESION TONS/SQ.FT.
SHELL 0.60 0
SLIDE 0.45 0
CORE 0.30 0
FOUNDATION 0.185 0.20
EL. ABOVE PRESENT RING DAM
TOP F. SHALE
F.S. = 2.0
F.S. = 1.64

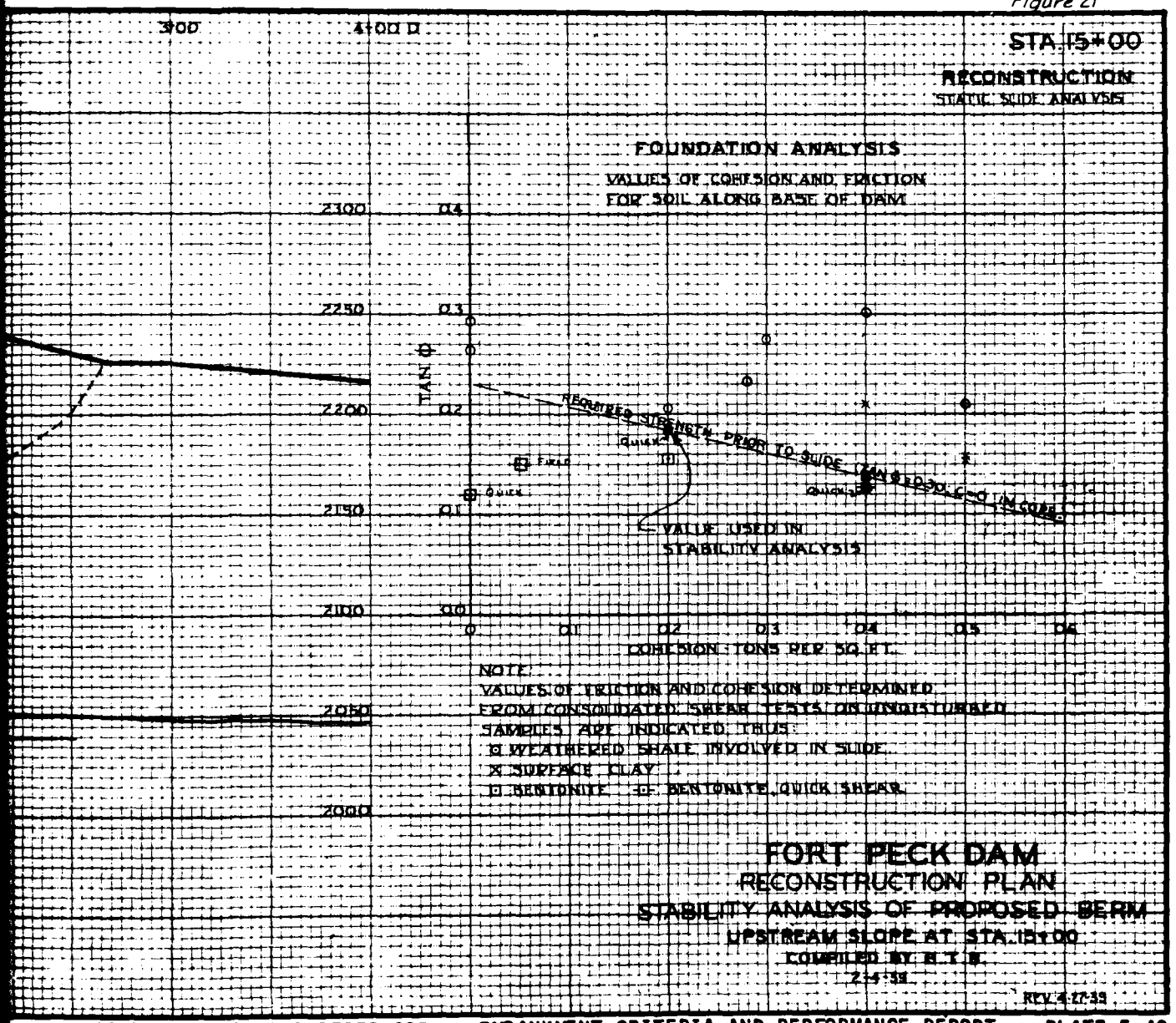
3


3+00
2+00
1+00 U
AXIS
1+00 D
2+00
3+00
EL 2275.5
X A
2212 BERM
SATURATION LINE
OF PRESENT RING DAM
CORE LIMITS
TOP OF STRIPPED GROUND
SHALE

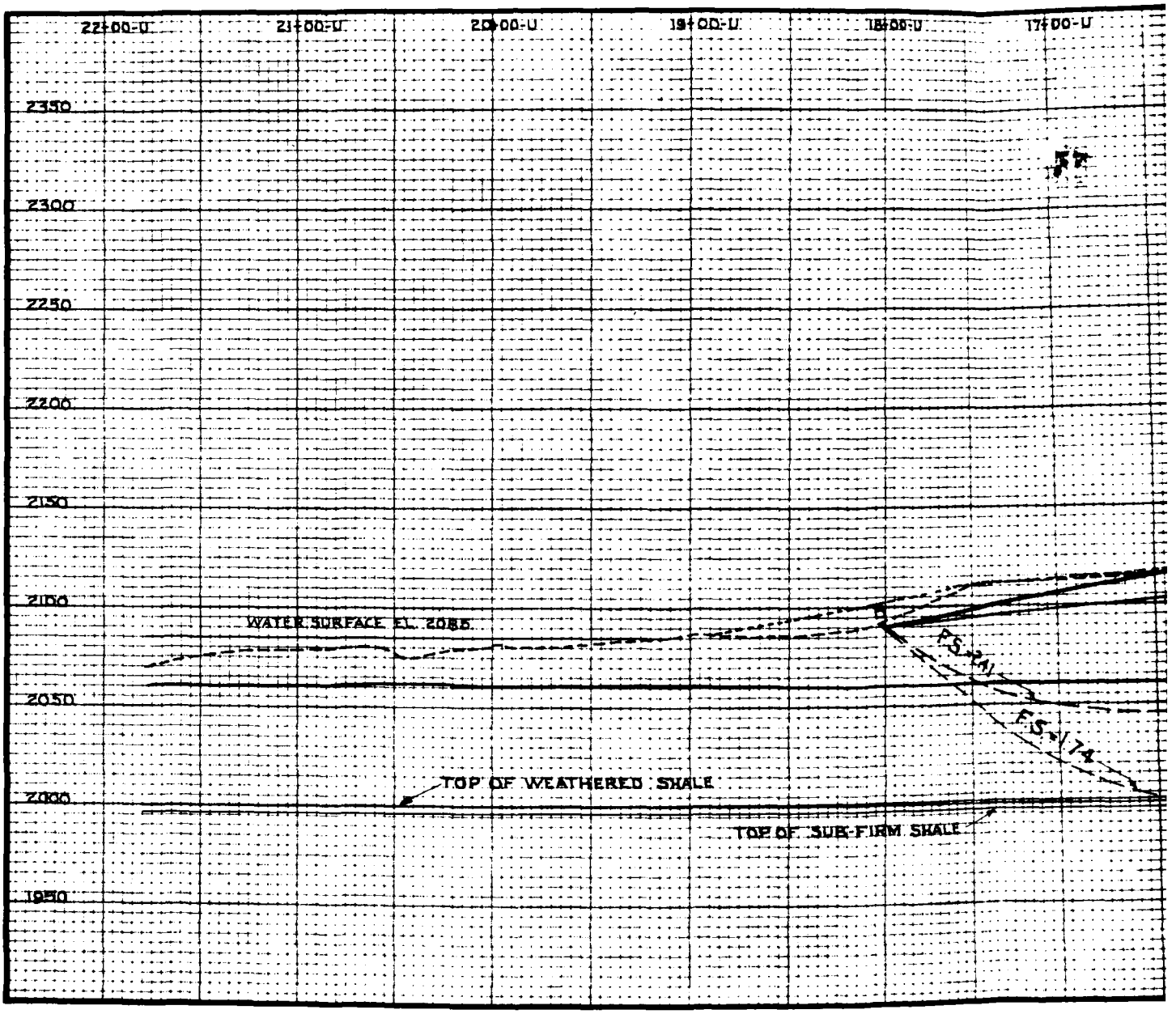
FORT PECK

4

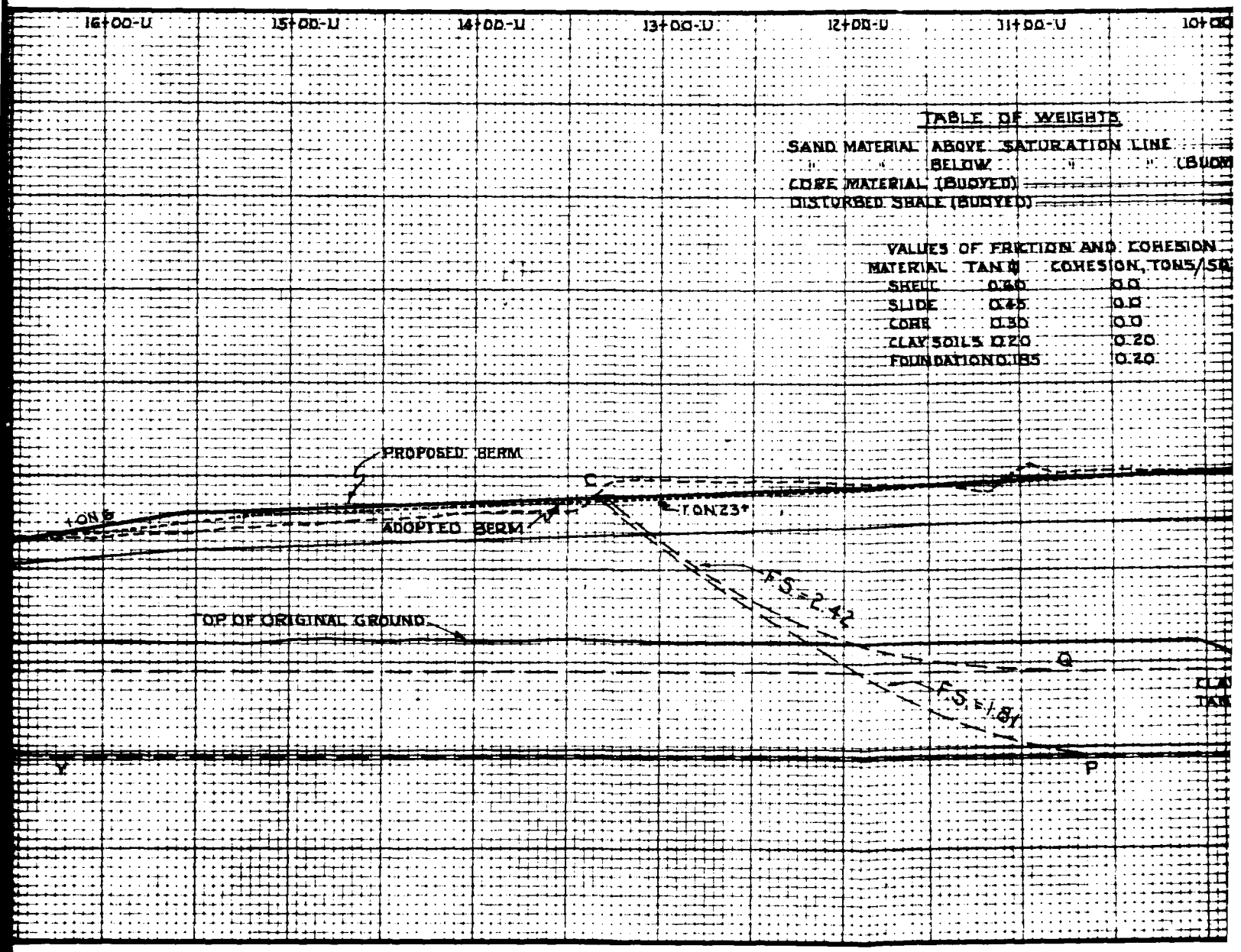
Figure 21


STA. 15+00
RECONSTRUCTION
STATIC SLIDE ANALYSIS
FOUNDATION ANALYSIS
VALUES OF COHESION AND FRICTION
FOR SOIL ALONG BASE OF DAM
ELEVATION
2100
2250
2200
2150
2000
2050
04
03
02
01
00
REQUIRED STRENGTH PRIOR TO SLIDE
VALUE USED IN
STABILITY ANALYSIS
COHESION TONS PER SQ. FT.
NOTE
VALUES OF FRICTION AND COHESION DETERMINED
FROM CONSOLIDATED SHEAR TESTS ON UNDISTURBED
SAMPLES ARE INDICATED THUS
WEATHERED SHALE INVOLVED IN SLIDE
SURFACE CLAY
BENTONITE
BENTONITE, QUICK SHEAR
FORT PECK DAM
RECONSTRUCTION PLAN
STABILITY ANALYSIS OF PROPOSED BERM
UPSTREAM SLOPE AT STA. 15+00
COMPILED BY B.T.B.
2-4-39
REV. 4-17-39

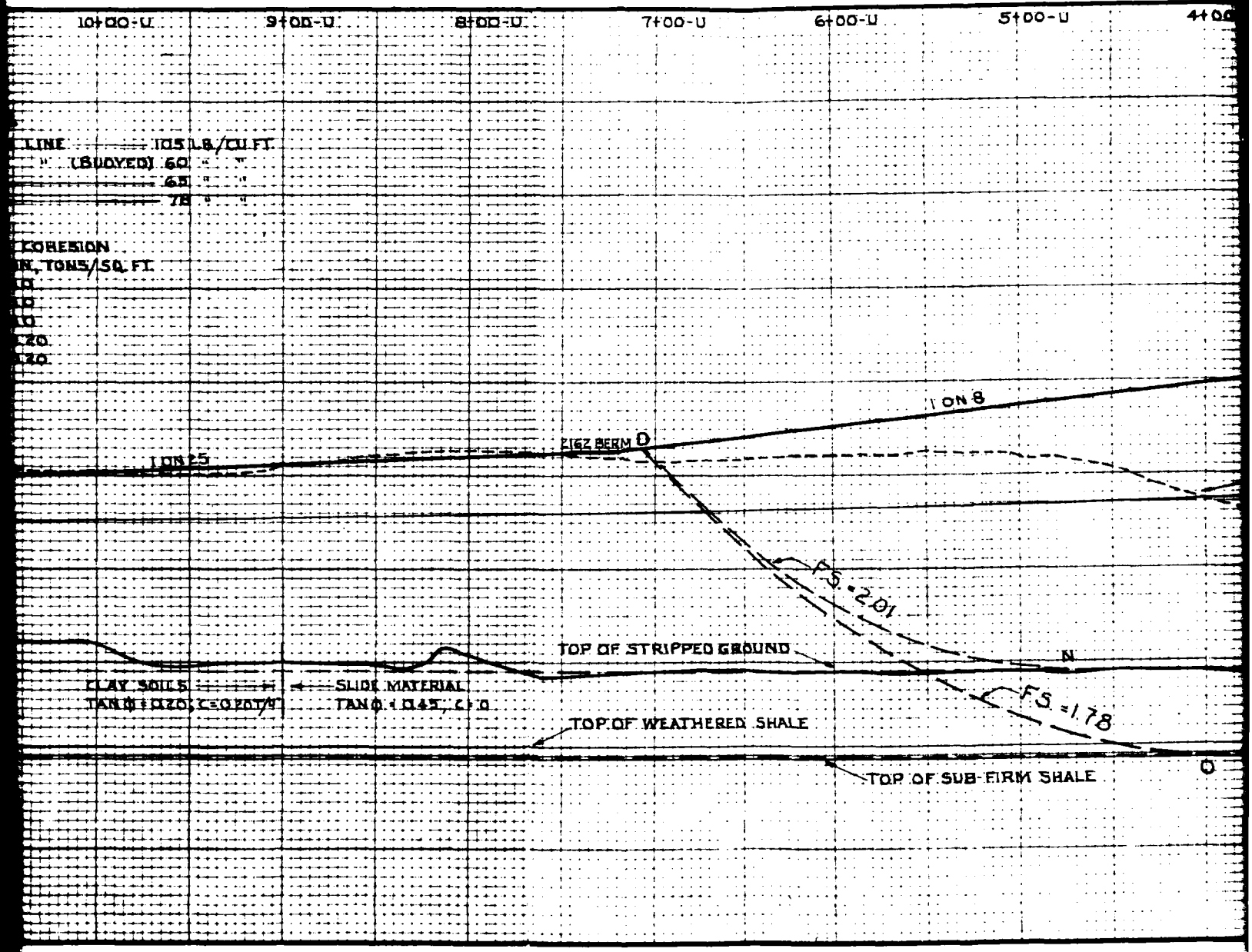
5


22+00-U
21+00-U
20+00-U
19+00-U
18+00-U
17+00-U
2350
2300
2250
2200
2150
2100
2050
2000
1950
WATER SURFACE EL. 2085
TOP OF WEATHERED SHALE
TOP OF SUB-FIRM SHALE

(Face p. 16) No. 6


16+00-U
15+00-U
14+00-U
13+00-U
12+00-U
11+00-U
10+00
TABLE OF WEIGHTS
SAND MATERIAL ABOVE SATURATION LINE
" " BELOW " " (BUOY
CORE MATERIAL (BUOYED)
DISTURBED SHALE (BUOYED)
VALUES OF FRICTION AND COHESION
MATERIAL TAN ϕ COHESION, TONS/SQ
SHELL 0.60 0.0
SLIDE 0.45 0.0
CORE 0.30 0.0
CLAY SOILS 0.20 0.20
FOUNDATION 0.185 0.20
PROPOSED BERM
ADOPTED BERM
TON 23°
TON 23°
TOP OF ORIGINAL GROUND
C
Q
P
Y

2


10+00-U
9+00-U
8+00-U
7+00-U
6+00-U
5+00-U
4+00
LINE ——— 105 LB./CU FT.
" (BUOYED) 60 " "
65 " "
78 " "
COHESION
IN, TONS/SQ. FT.
1 ON 8
1 ON 2.5
FIG2 BERM
FS = 2.01
FS = 1.78
TOP OF STRIPPED GROUND
N
CLAY SOILS
TAN Φ = 0.20, C = 0 PSF
SLIDE MATERIAL
TAN Φ = 0.45, C = 0
TOP OF WEATHERED SHALE
TOP OF SUB-FIRM SHALE
O

3

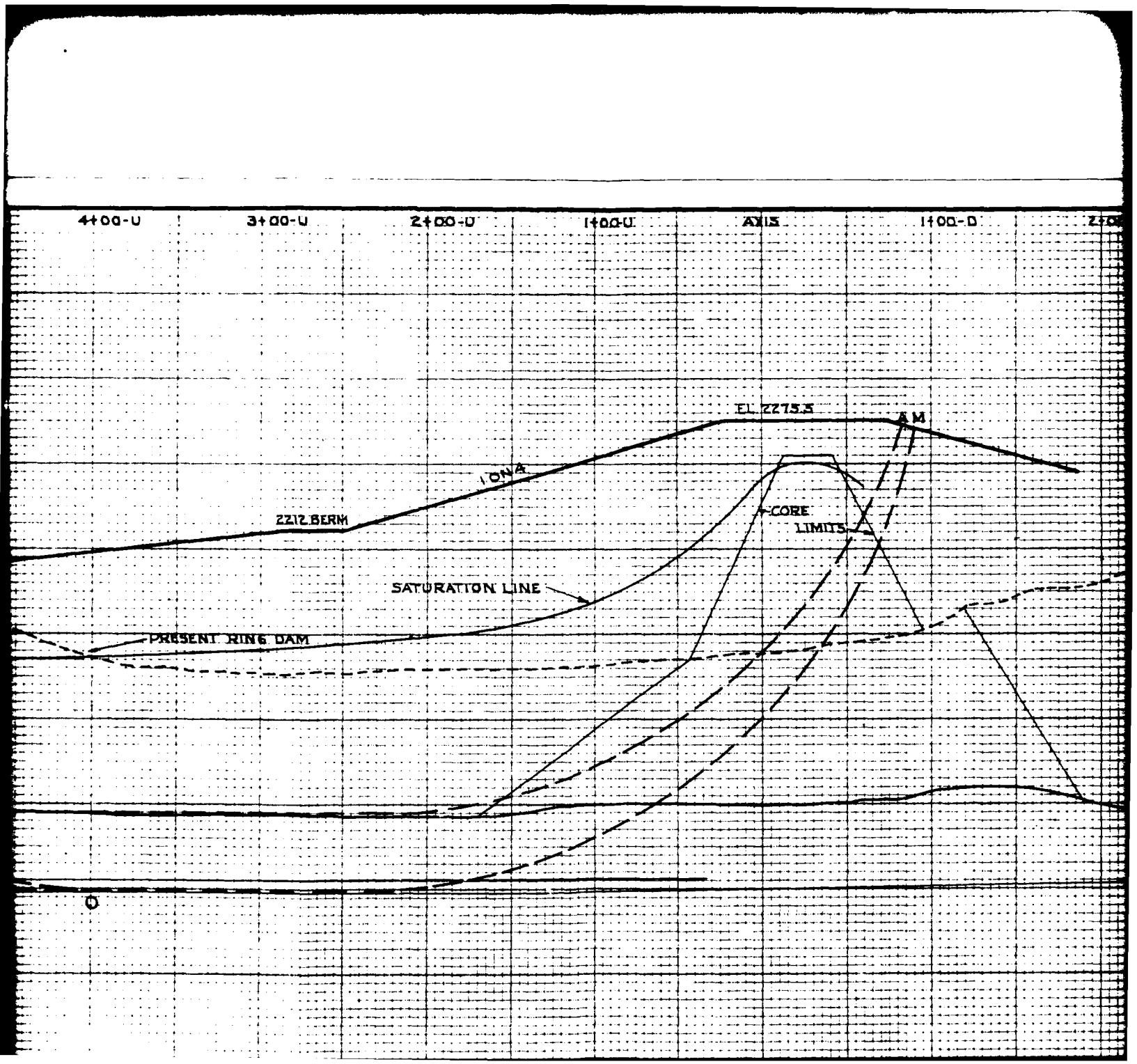
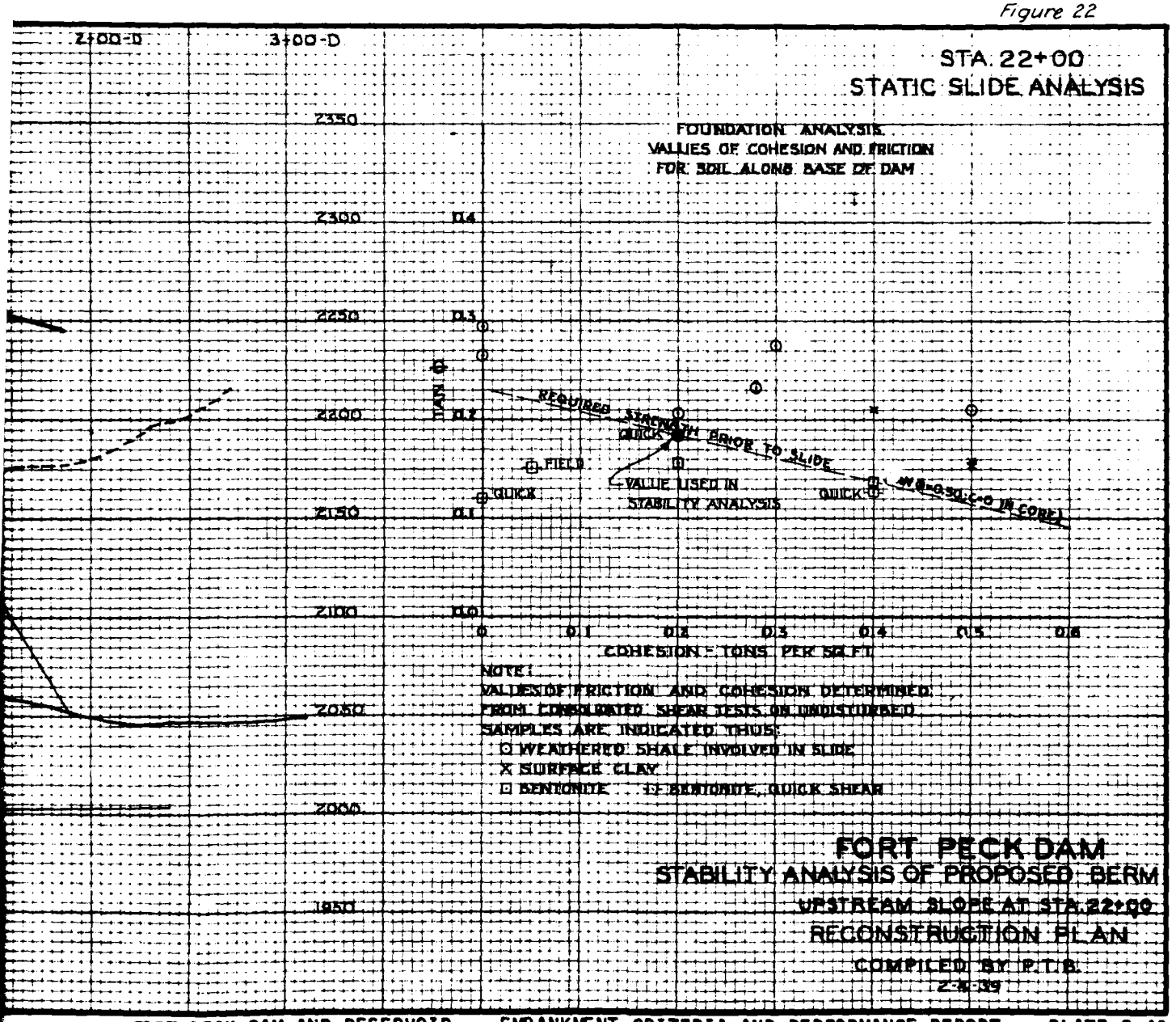

4+00-U
3+00-U
2+00-U
1+00-U
AXIS
1+00-D
EL 2275.5
A M
IONA
2212 BERM
CORE
LIMITS
SATURATION LINE
PRESENT RING DAM
0

Figure 22



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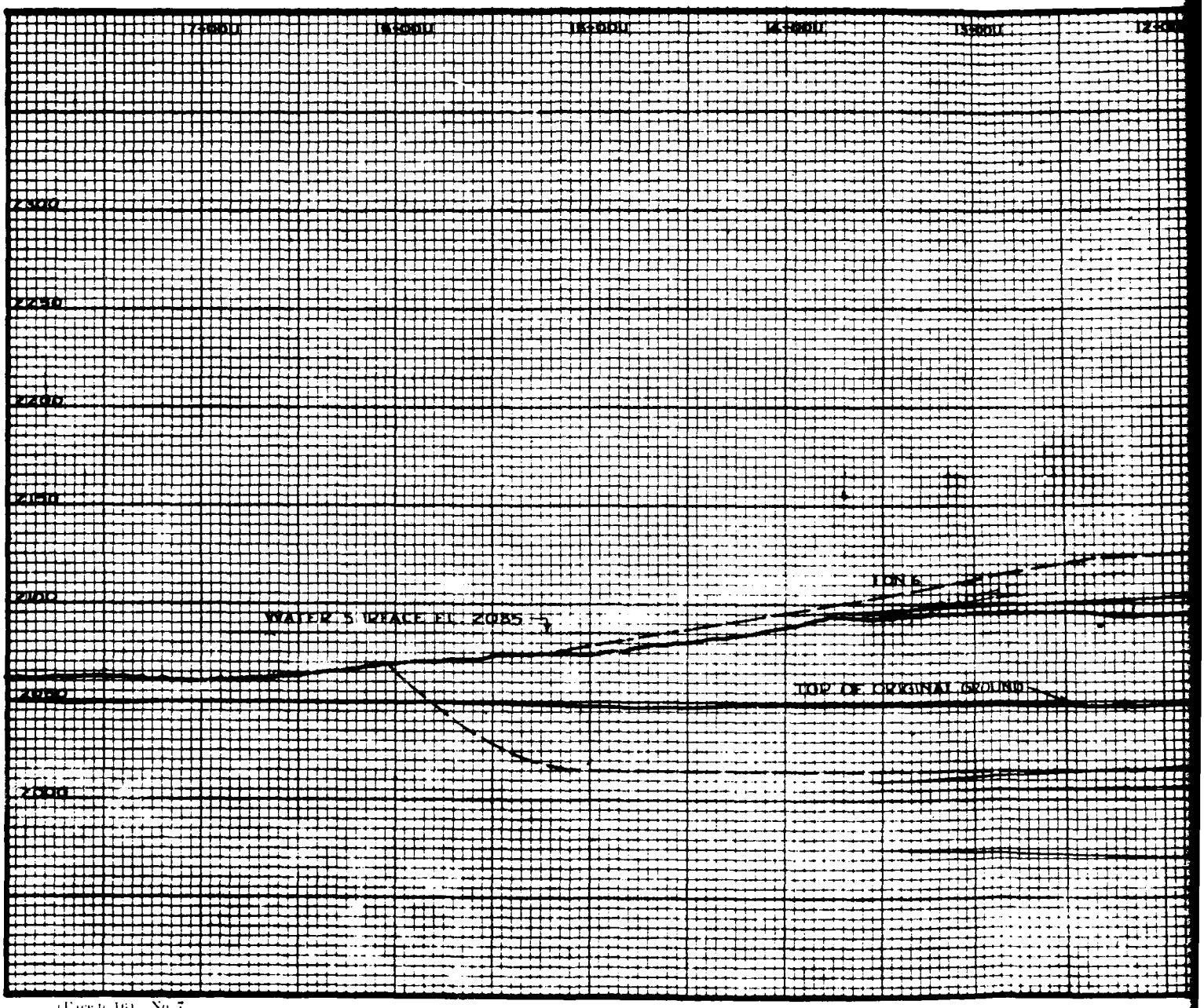
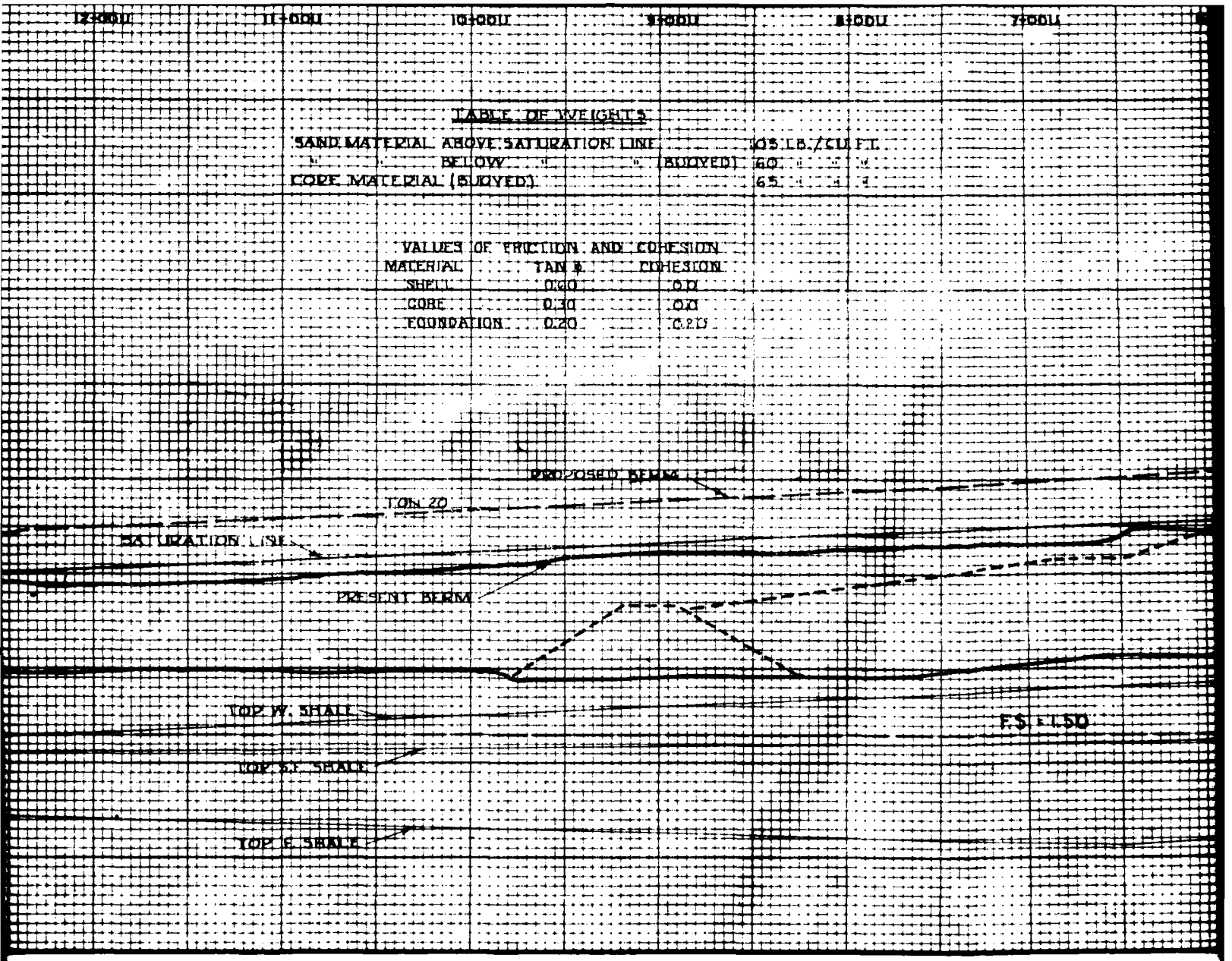
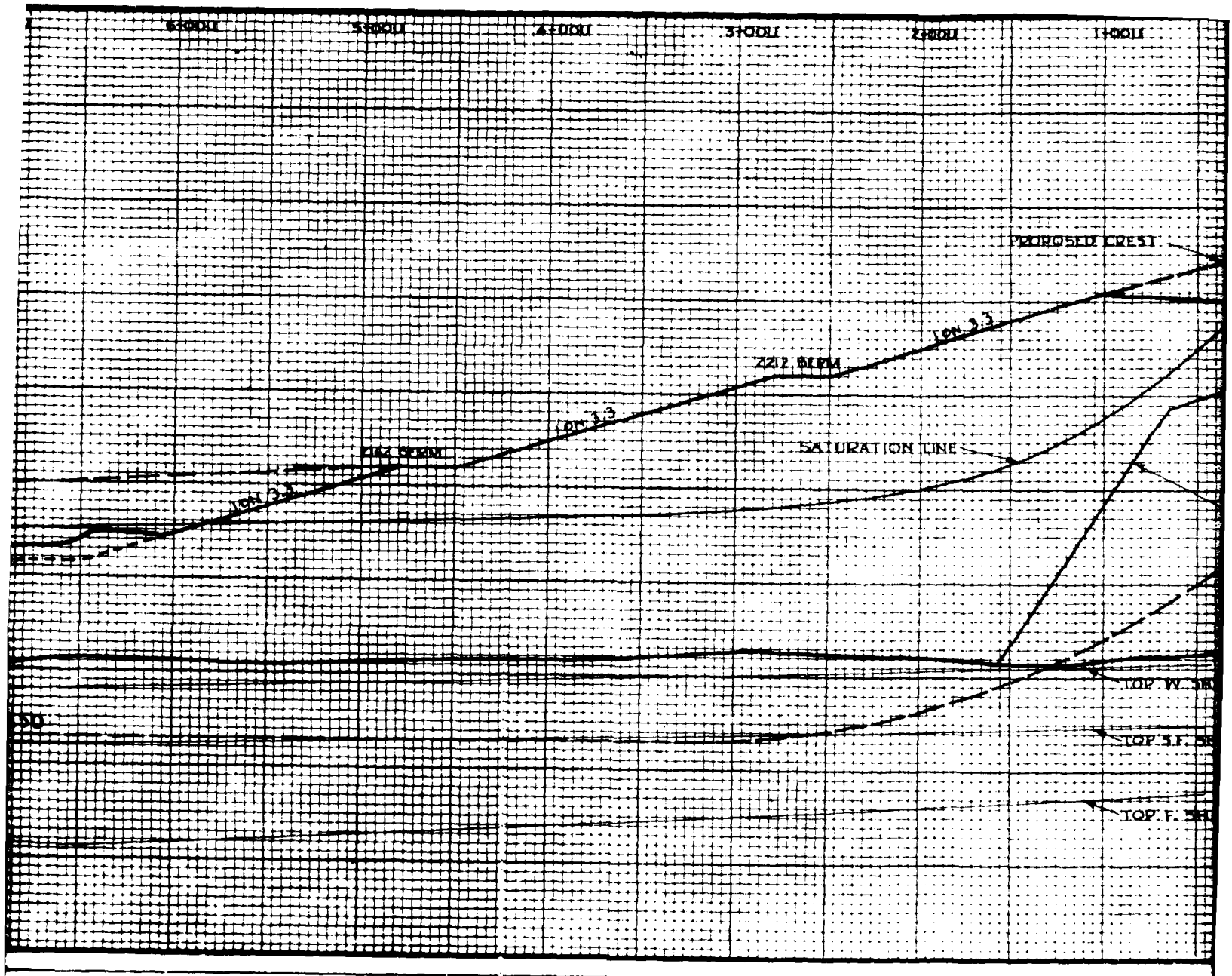
5'


17+000
16+000
15+000
14+000
13000
2300
2250
2200
2150
2100
2050
2000
WATER SURFACE EL. 2085
TOP OF ORIGINAL GROUND

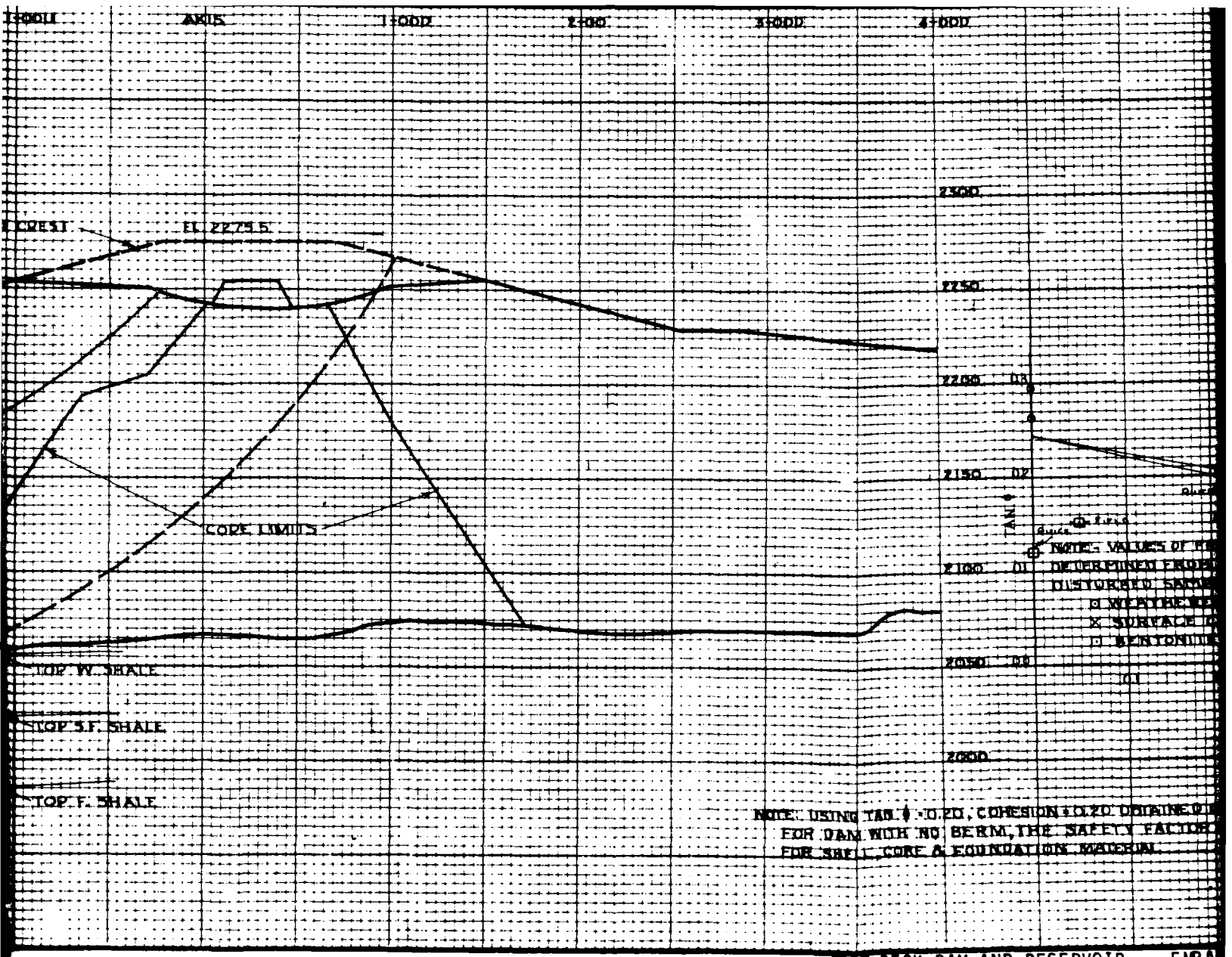
(Page 161 No. 7


12+00U
11+00U
10+00U
9+00U
8+00U
7+00U
TABLE OF WEIGHTS
SAND MATERIAL ABOVE SATURATION LINE 105 LB./CU. FT.
" BELOW " " (BUOYED) 60 " "
CORE MATERIAL (BUOYED) 65 " "
VALUES OF FRICTION AND COHESION
MATERIAL TAN ϕ COHESION
SHELL 0.60 0.01
CORE 0.30 0.01
FOUNDATION 0.20 0.25
PROPOSED BERM
TOP EL 20
SATURATION LINE
PRESENT BERM
TOP W. SHALE
TOP E.F. SHALE
TOP E. SHALE
F.S. = 1.50

2



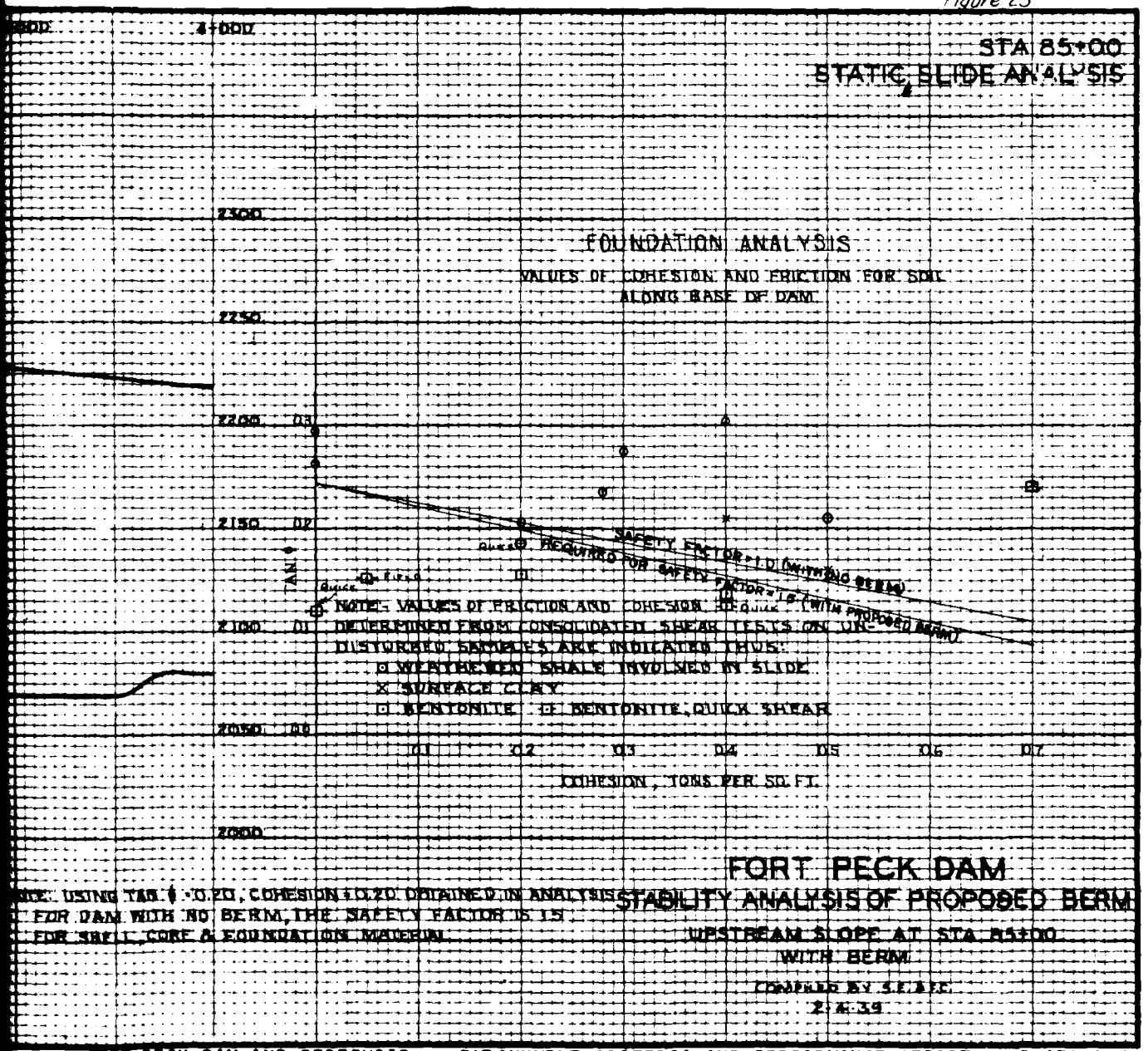
3



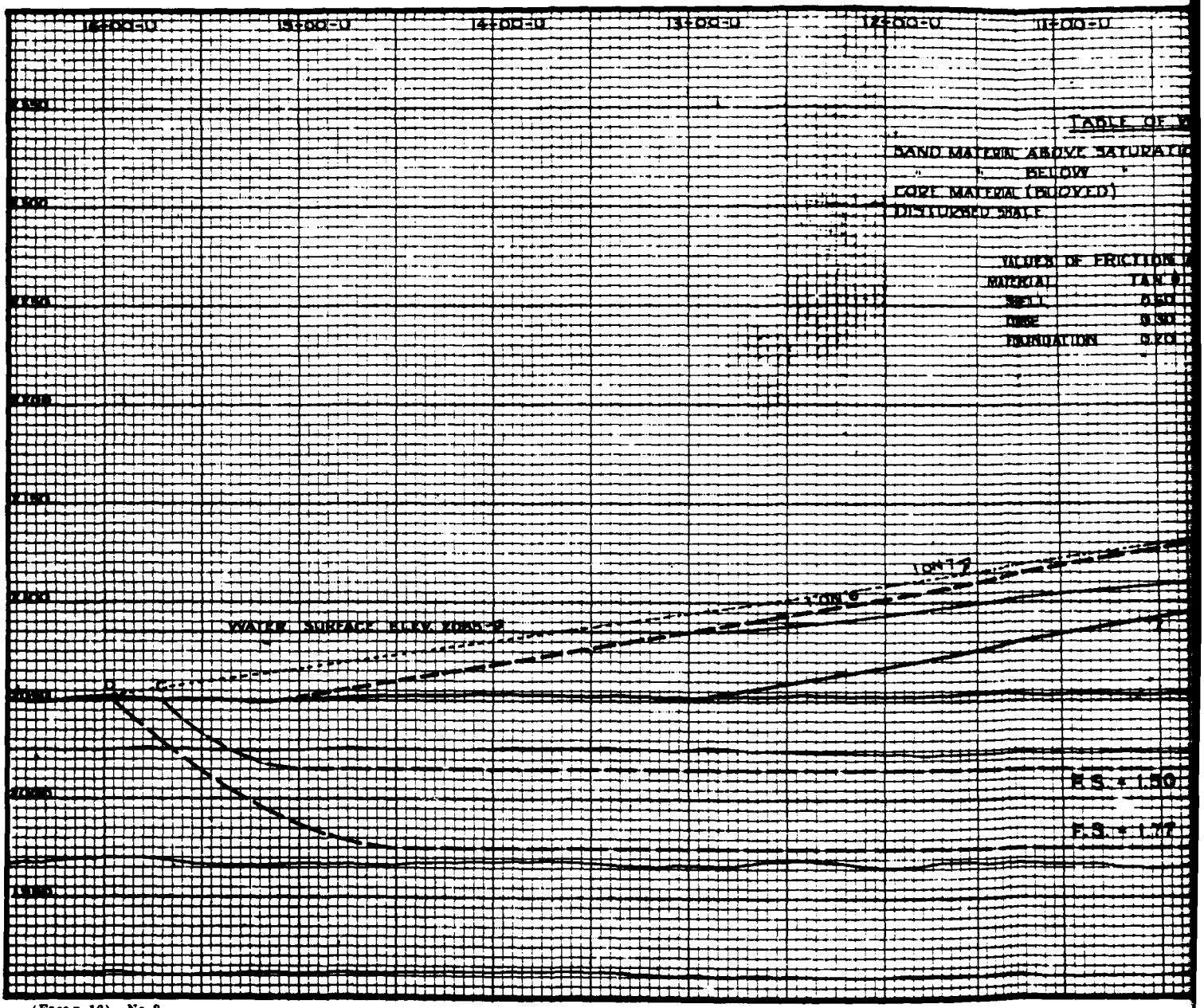
FORT PECK DAM AND RESERVOIR EI8A

4

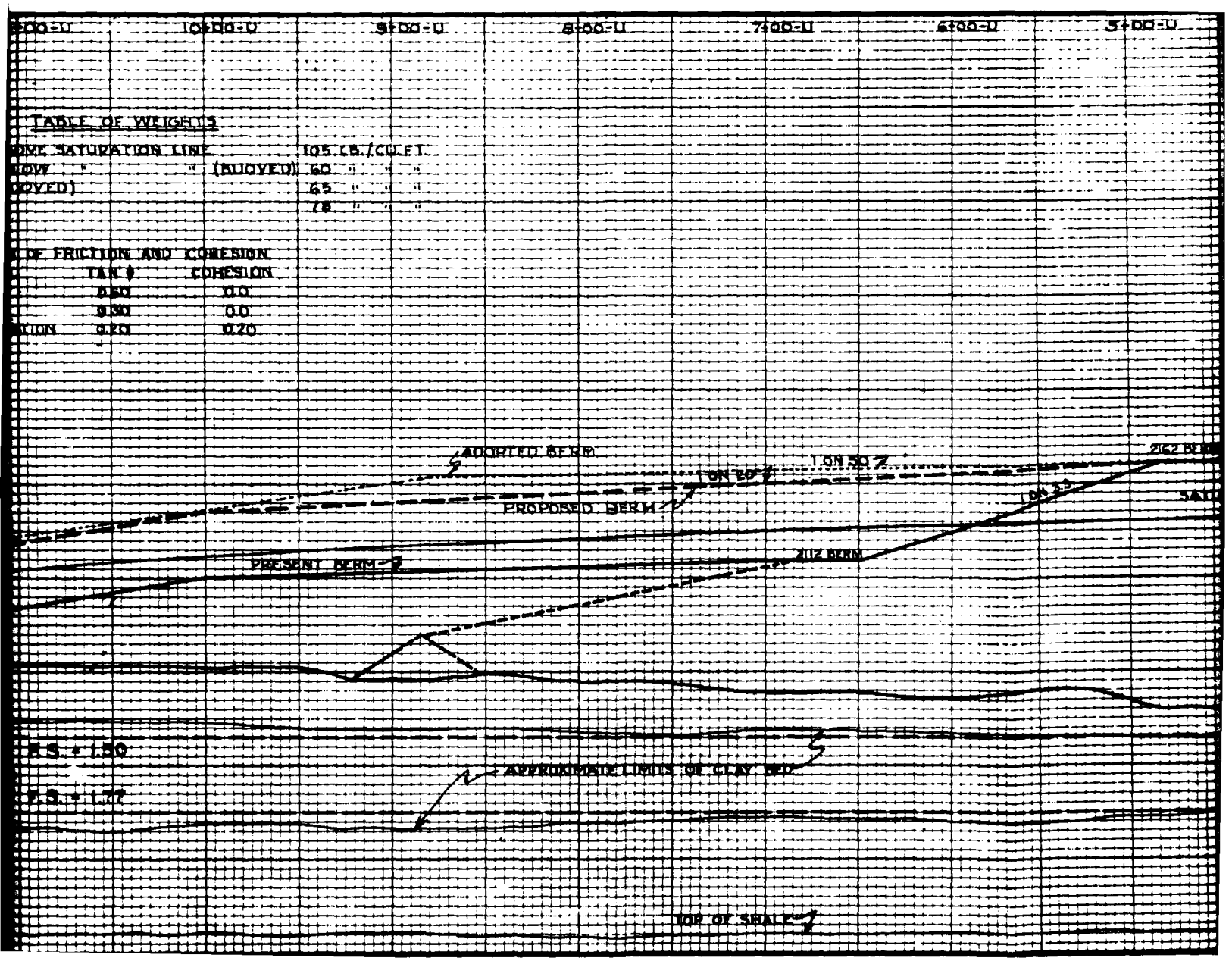
Figure 23


4+00D
STA 85+00
STATIC SLIDE ANALYSIS
Z300
Z250
Z200
Z150
Z100
Z050
Z000
FOUNDATION ANALYSIS
VALUES OF COHESION AND FRICTION FOR SOIL ALONG BASE OF DAM
TAN
SAFETY FACTOR = 1.0 (WITHOUT BERM)
REQUIRED FOR SAFETY FACTOR = 1.5 (WITH PROPOSED BERM)
NOTE: VALUES OF FRICTION AND COHESION DETERMINED FROM CONSOLIDATED SHEAR TESTS ON UNDISTURBED SAMPLES ARE INDICATED THUS:
WEATHERED SHALE INVOLVED IN SLIDE
SURFACE CLAY
BENTONITE
BENTONITE, QUICK SHEAR
D1
D2
D3
D4
D5
D6
D7
COHESION, TONS PER SQ. FT.
FORT PECK DAM
STABILITY ANALYSIS OF PROPOSED BERM
UPSTREAM SLOPE AT STA 85+00
WITH BERM
COMPILED BY S.E.A.F.C.
2-4-39
NOTE: USING TAN φ = 0.20, COHESION = 0.20 OBTAINED IN ANALYSIS FOR DAM WITH NO BERM, THE SAFETY FACTOR IS 1.5 FOR SHELL, CORE & FOUNDATION MATERIAL

5


16+00=0
15+00=0
14+00=0
13+00=0
12+00=0
11+00=0
TABLE OF
SAND MATERIAL ABOVE SATURATI
" " BELOW "
CORE MATERIAL (BUOYED)
DISTURBED SHALE
VALUES OF FRICTION
MATERIAL
SHELL
CORE
FOUNDATION
WATER SURFACE ELEV. ZONE 2
ZONE 7
ZONE 6
F.S. = 1.50
F.S. = 1.77

(Face p. 16) No. 8


10+00-0
9+00-0
8+00-0
7+00-0
6+00-0
5+00-0
TABLE OF WEIGHTS
OME SATURATION LINE 105 LB./CU.FT.
ADOPTED BERM
1 ON 50
PROPOSED BERM
PRESENT BERM
F.S. = 1.50
F.S. = 1.77
APPROXIMATE LIMITS OF CLAY BED
TOP OF SHALE

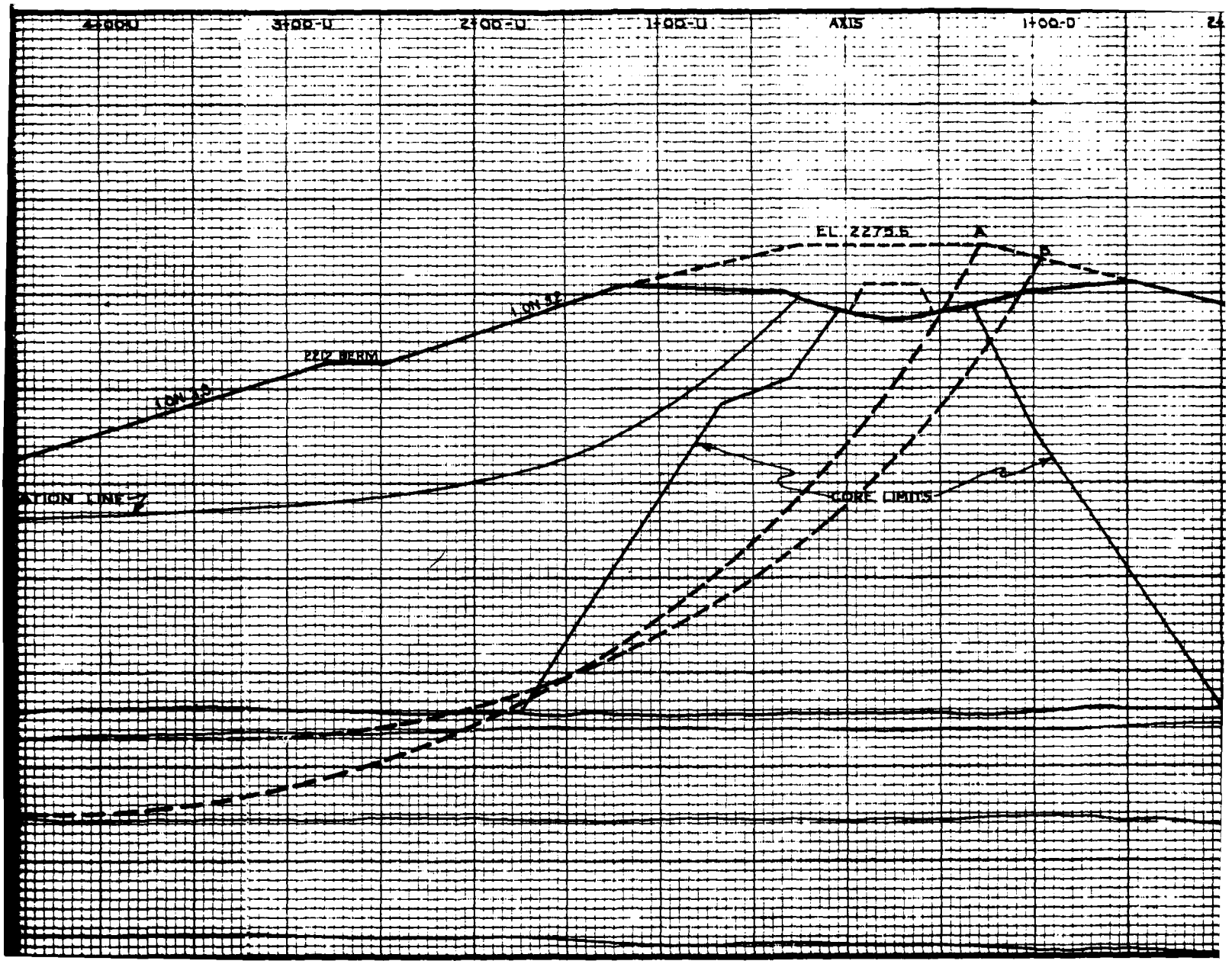
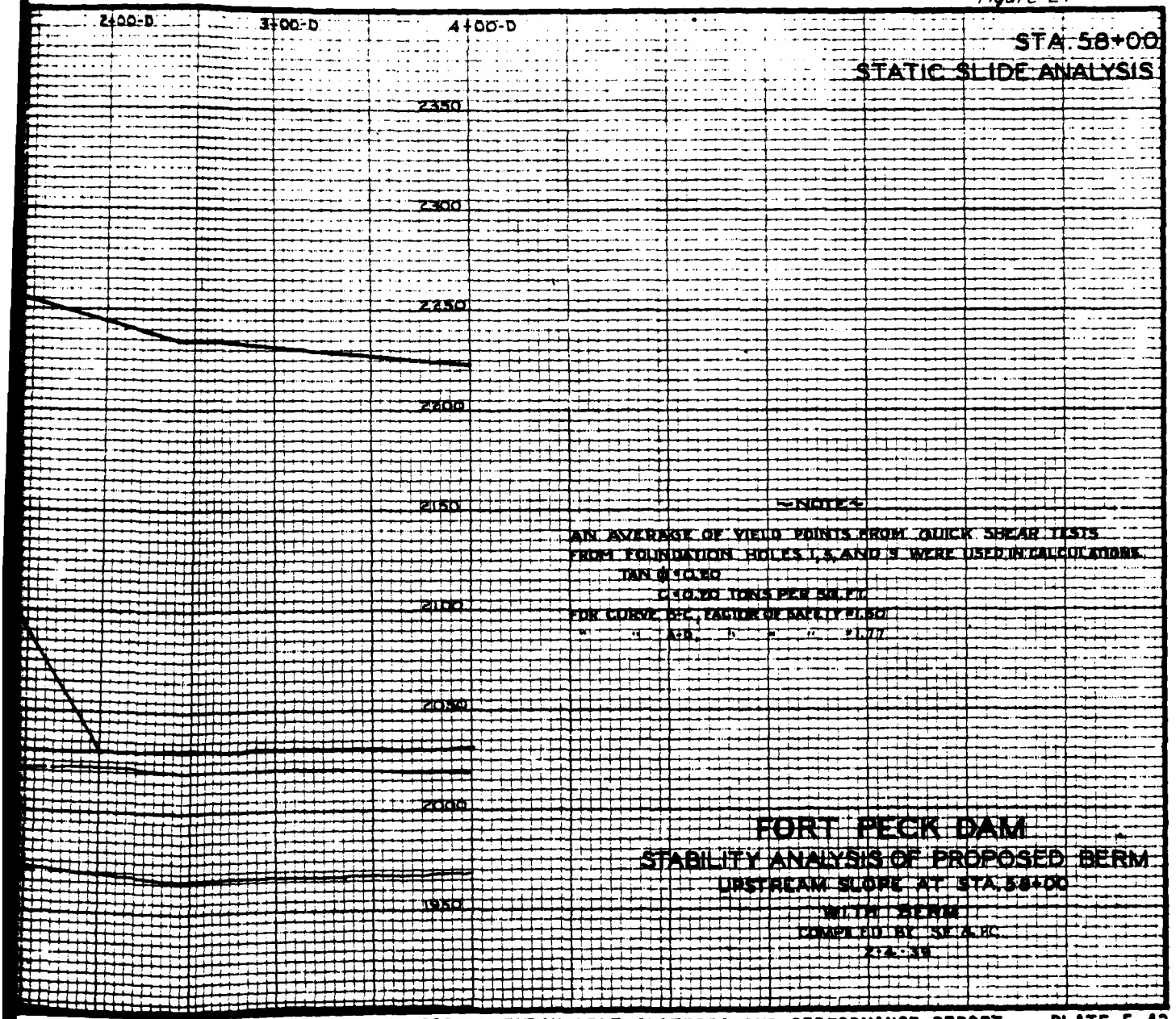

4+00-U
3+00-U
2+00-U
1+00-U
AXIS
1+00-D
EL. 2275.6
A
B
PZ12 BERM
CORE LIMITS

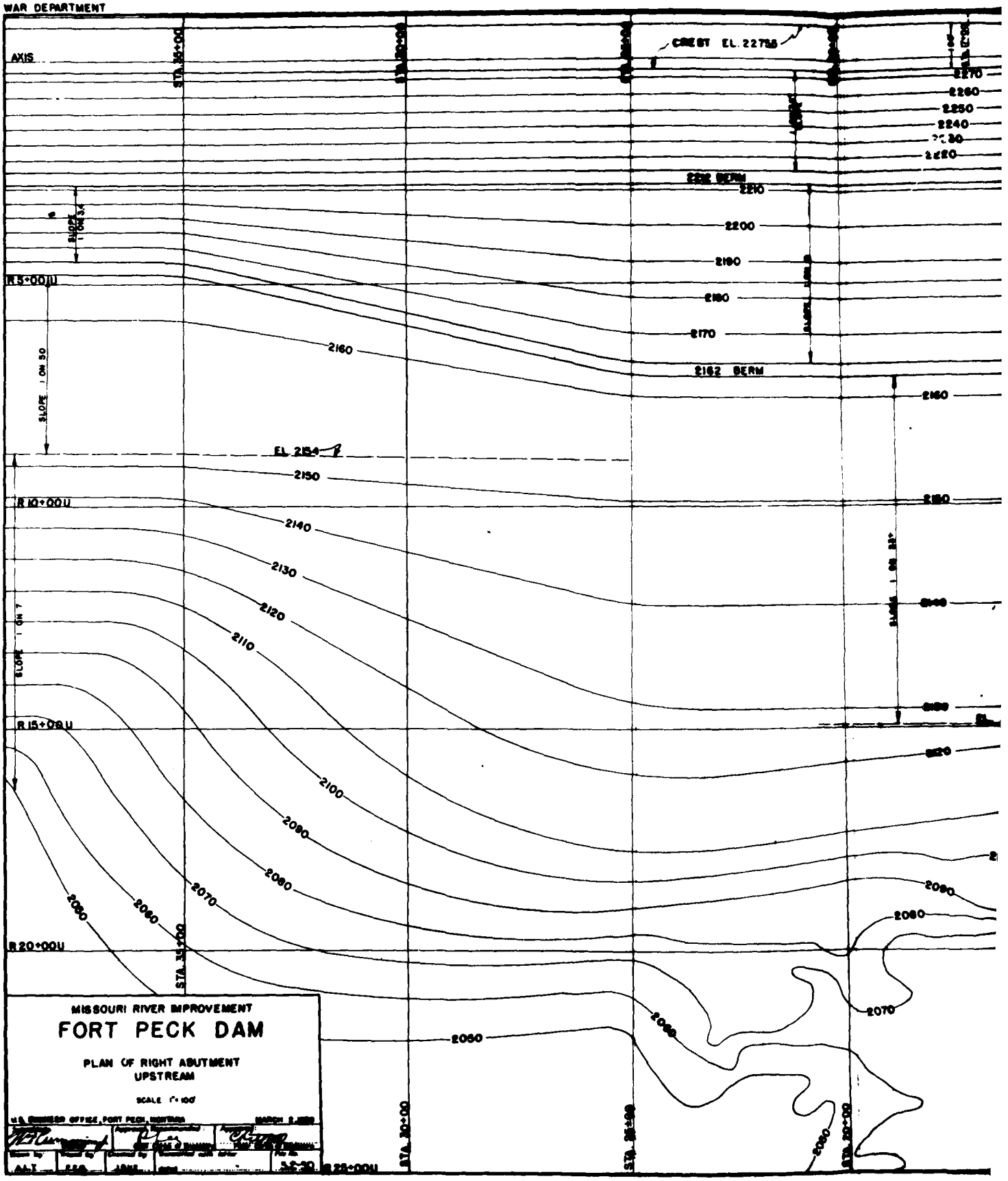
Figure 24



FORT PECK DAM AND RESERVOIR EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 5-43

4

WAR DEPARTMENT



MISSOURI RIVER IMPROVEMENT

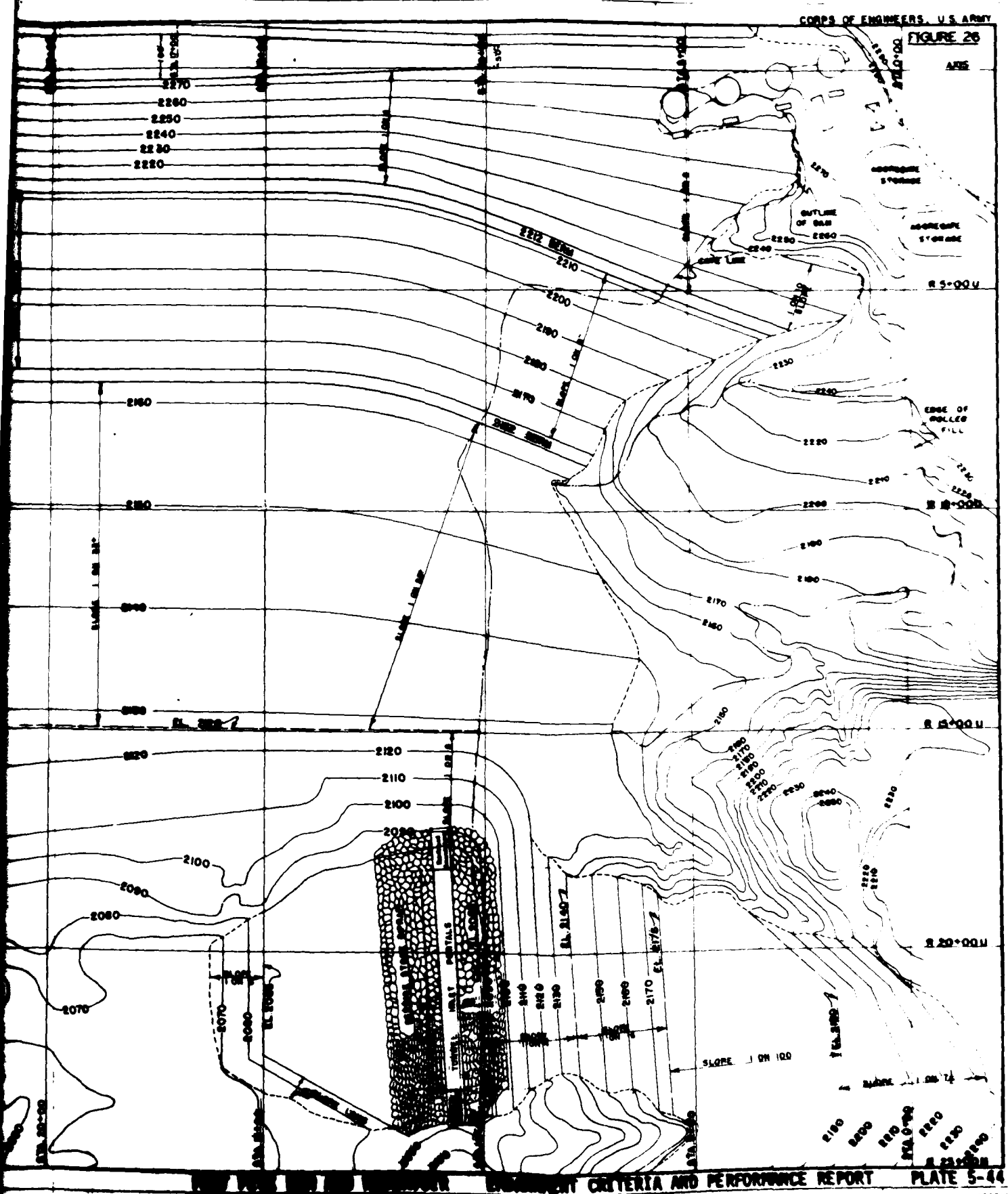
FORT PECK DAM

PLAN OF RIGHT ABUTMENT
UPSTREAM

SCALE 1" = 100'

U.S. ENGINEER OFFICE, FORT PECK, MONTANA — MARCH 8, 1938

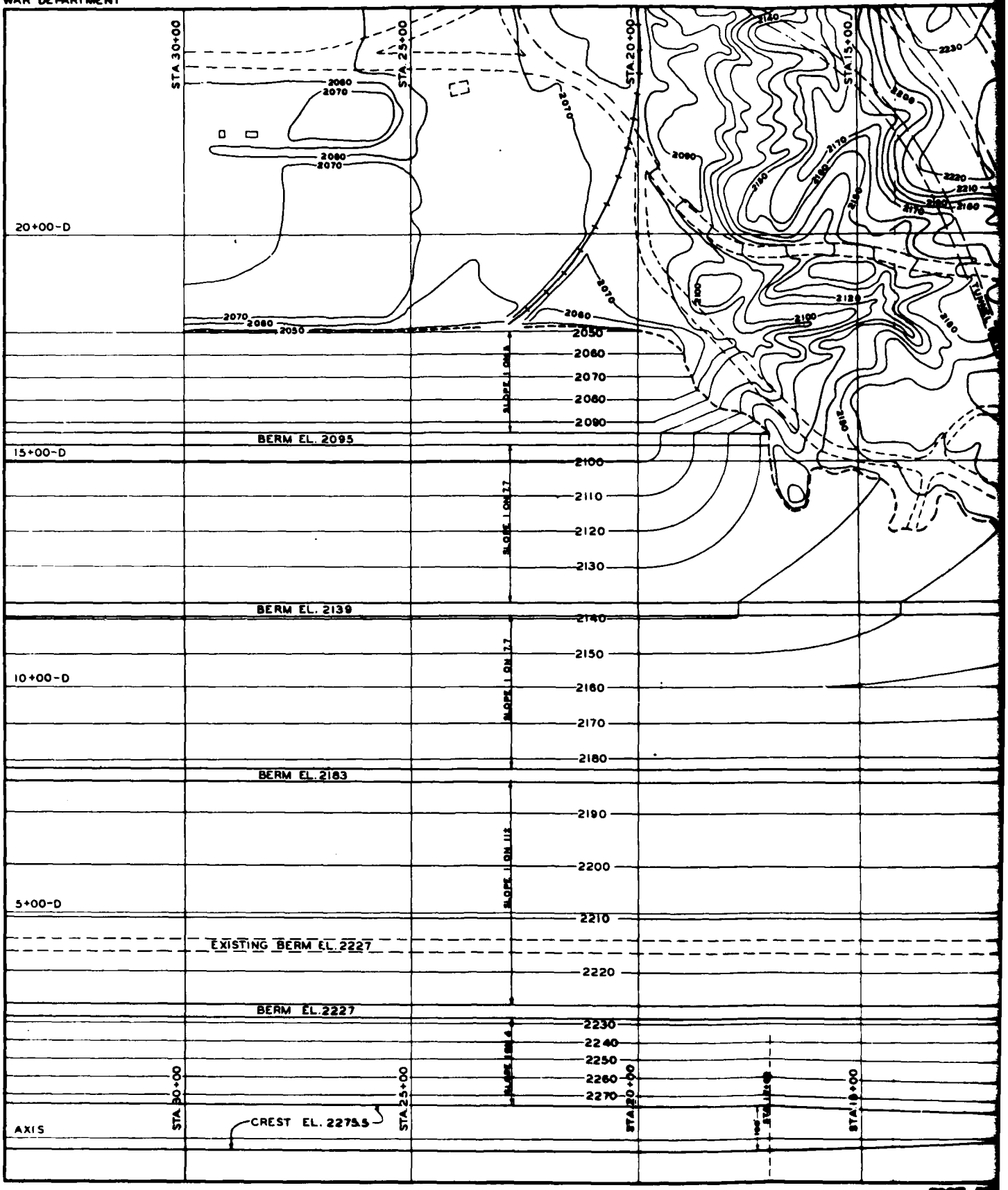
(Face p. 16) No. 10


CORPS OF ENGINEERS, U.S. ARMY
FIGURE 26
AXIS
OUTLINE OF GAS
EDGE OF ROLLED FILL
SLOPE 1 ON 120
R 5+00 U
R 10+00 U
R 15+00 U
R 20+00 U

G P O — 180810

2

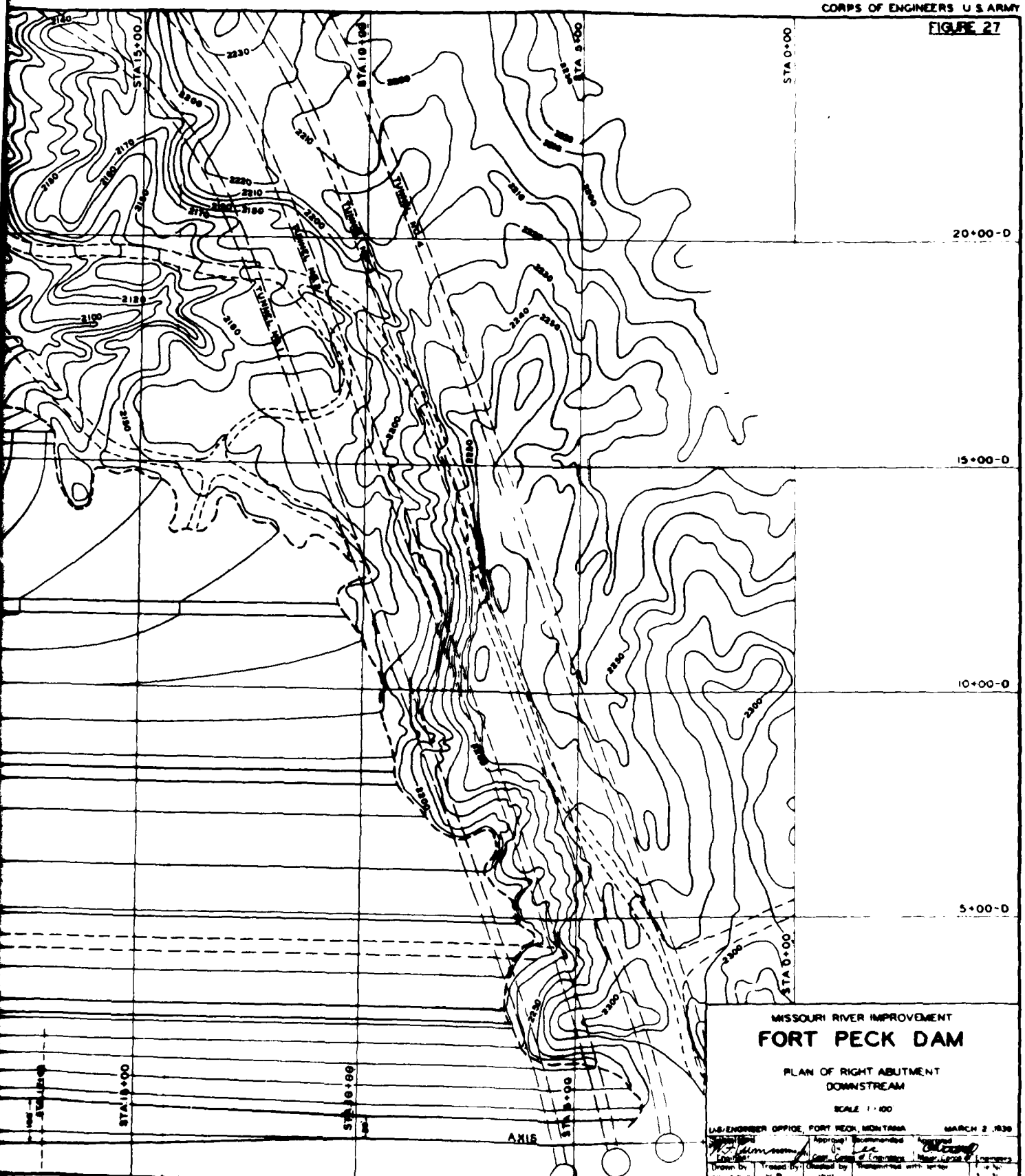
WAR DEPARTMENT



FORT R

CORPS OF ENGINEERS U S ARMY

FIGURE 27



MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

PLAN OF RIGHT ABUTMENT
DOWNSTREAM

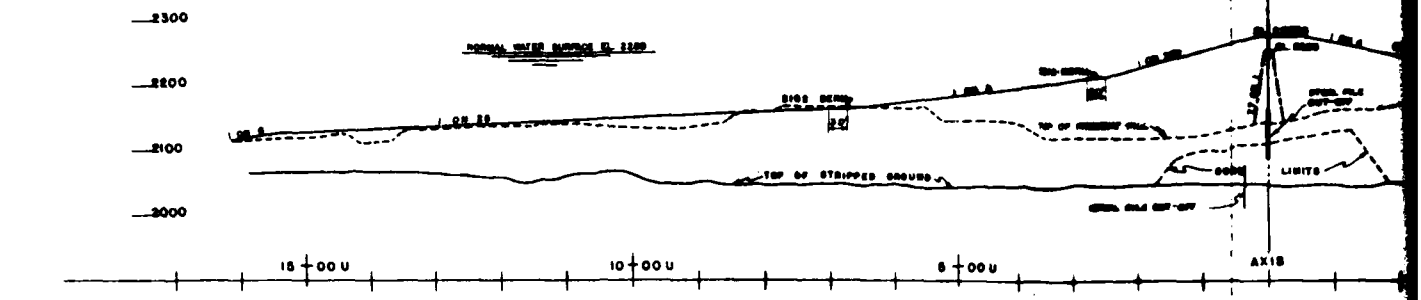
SCALE 1" = 100'

U.S. ENGINEER OFFICE, FORT PECK, MONTANA — MARCH 2, 1939

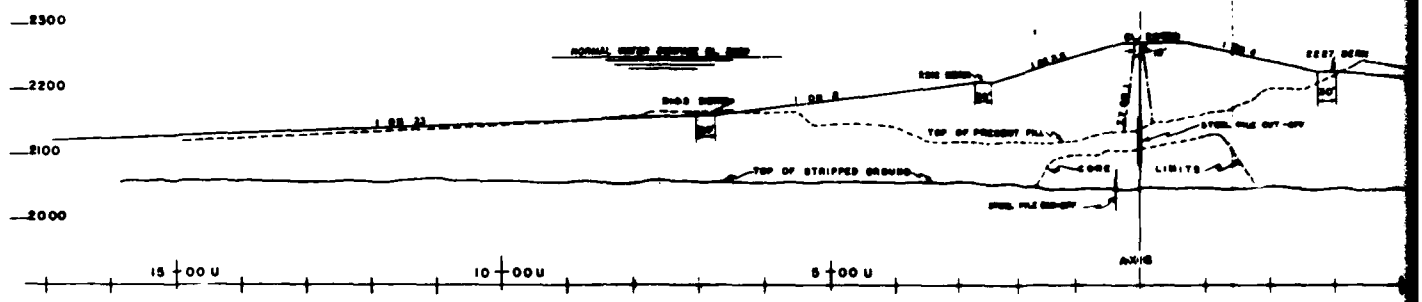
Submitted	Approved	Recommended	Approved
Junior Engr.	Asst. Engr.	Asst. Corps of Engineers	Major, Corps of Engineers

Drawn by	Traced by	Checked by	Photographed with letter
COL & ELA	H B	JBH	

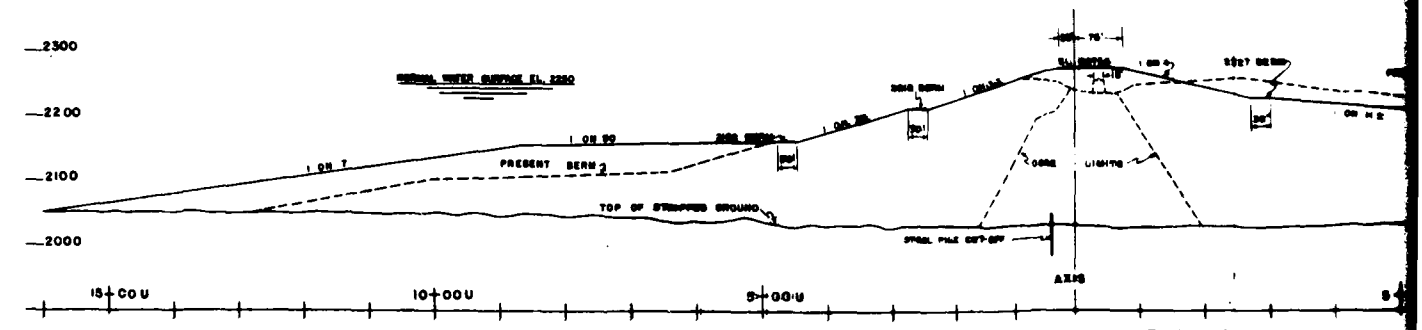
WAR DEPARTMENT



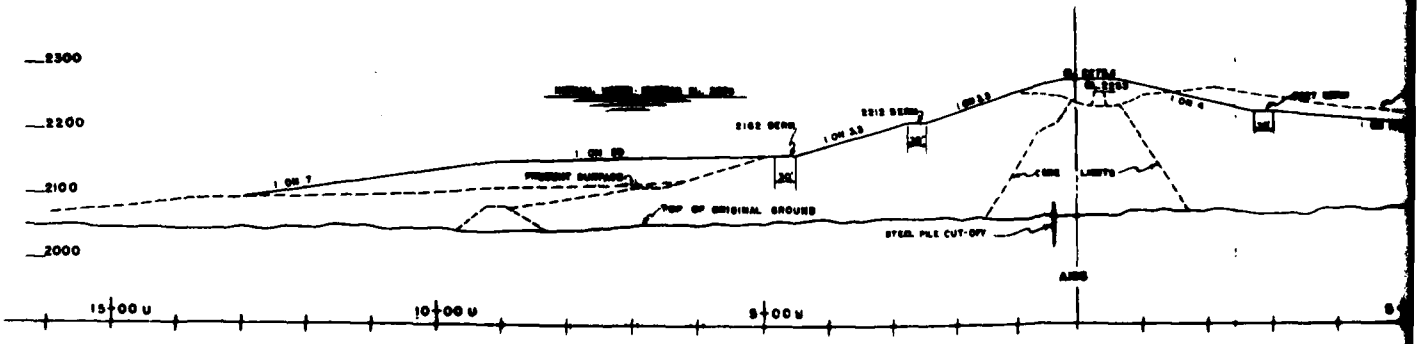
STA. 15+00



STA. 20+00



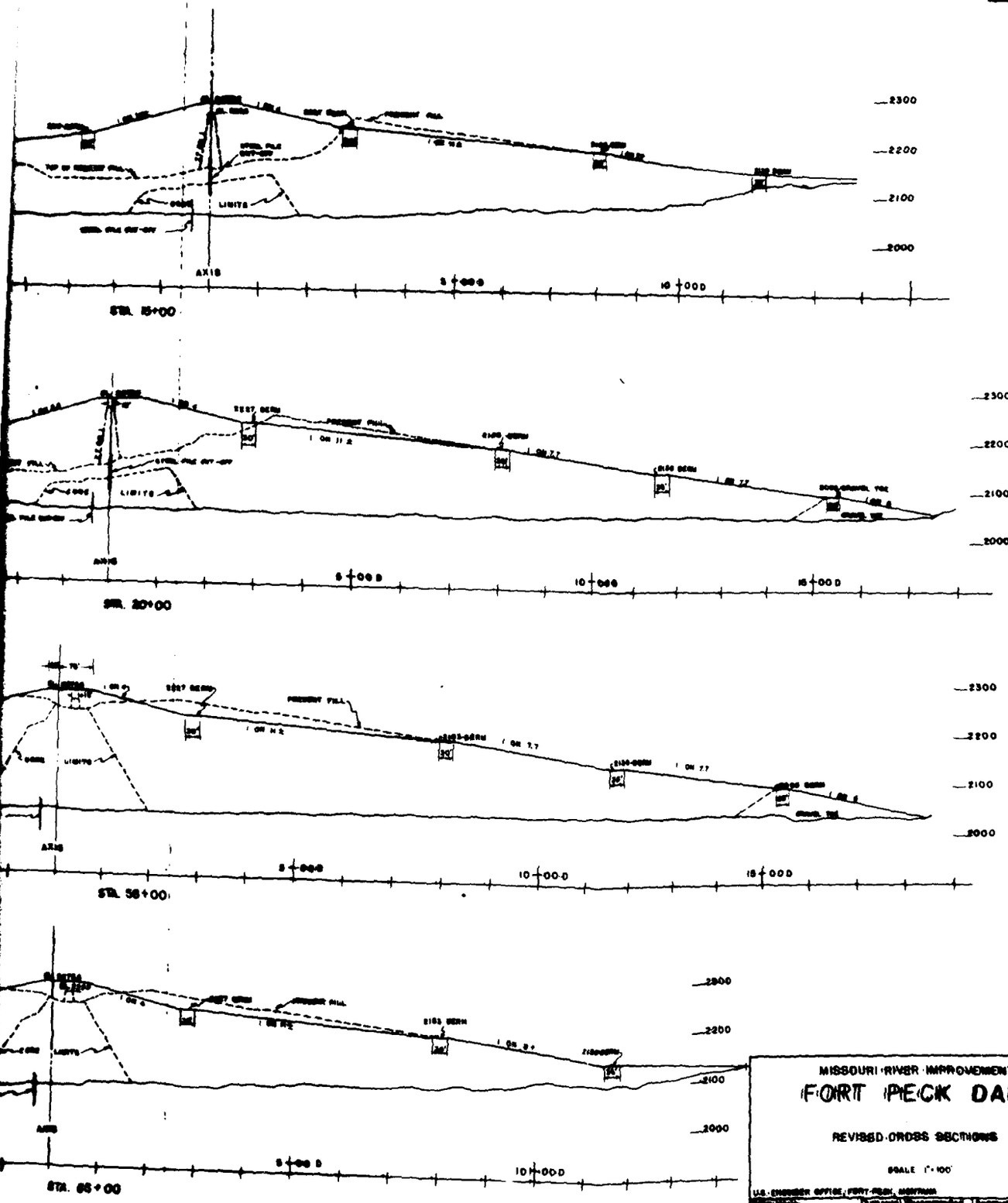
STA. 58+00



STA. 85+00

(Face p. 16) No. 9

FIGURE 25



MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

REVISED CROSS SECTIONS

SCALE 1" = 100'

U.S. ENGINEER OFFICE, FORT PECK, MONTANA — MARCH 2, 1939

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T.J.	S.M.M.			32.23

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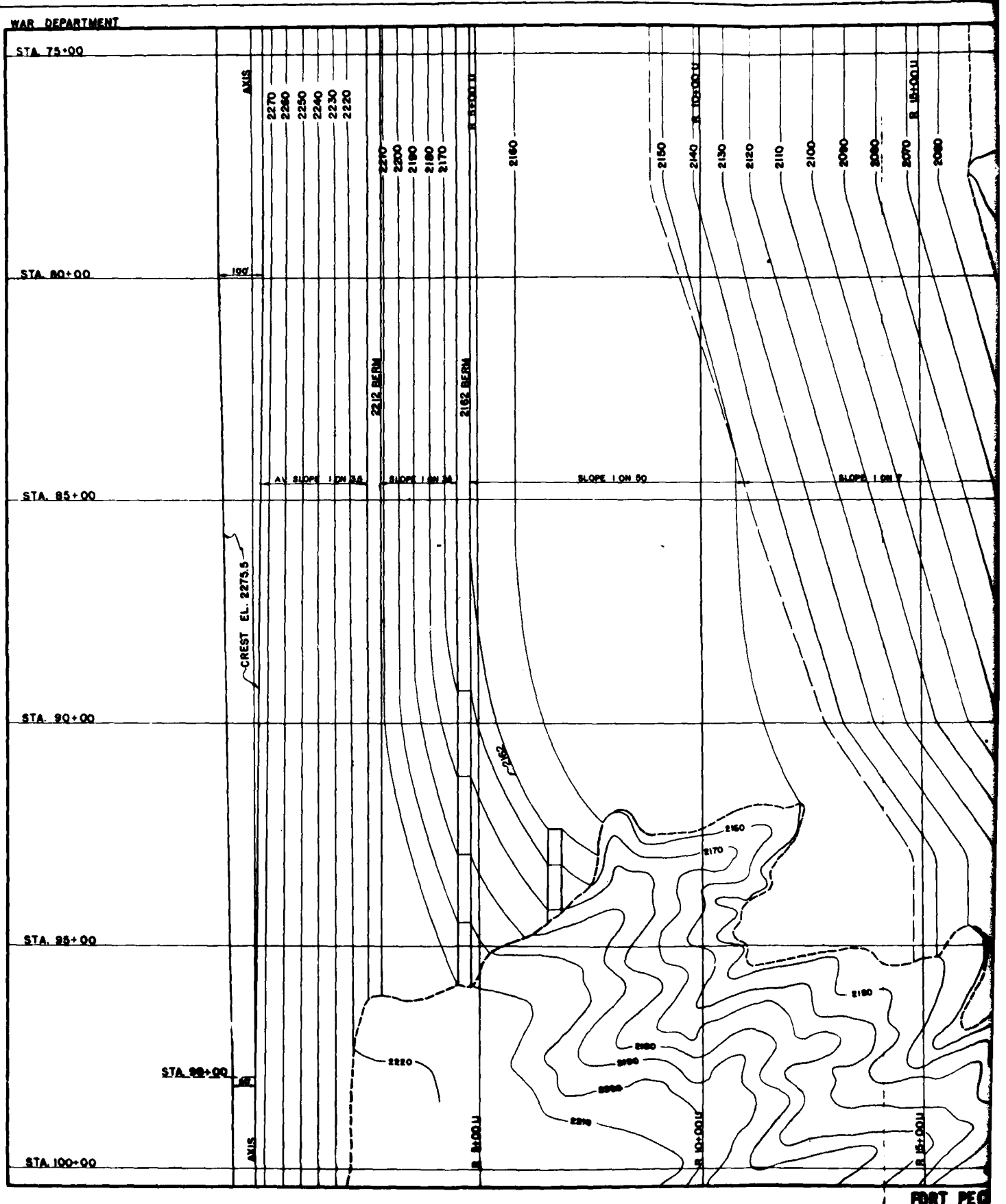
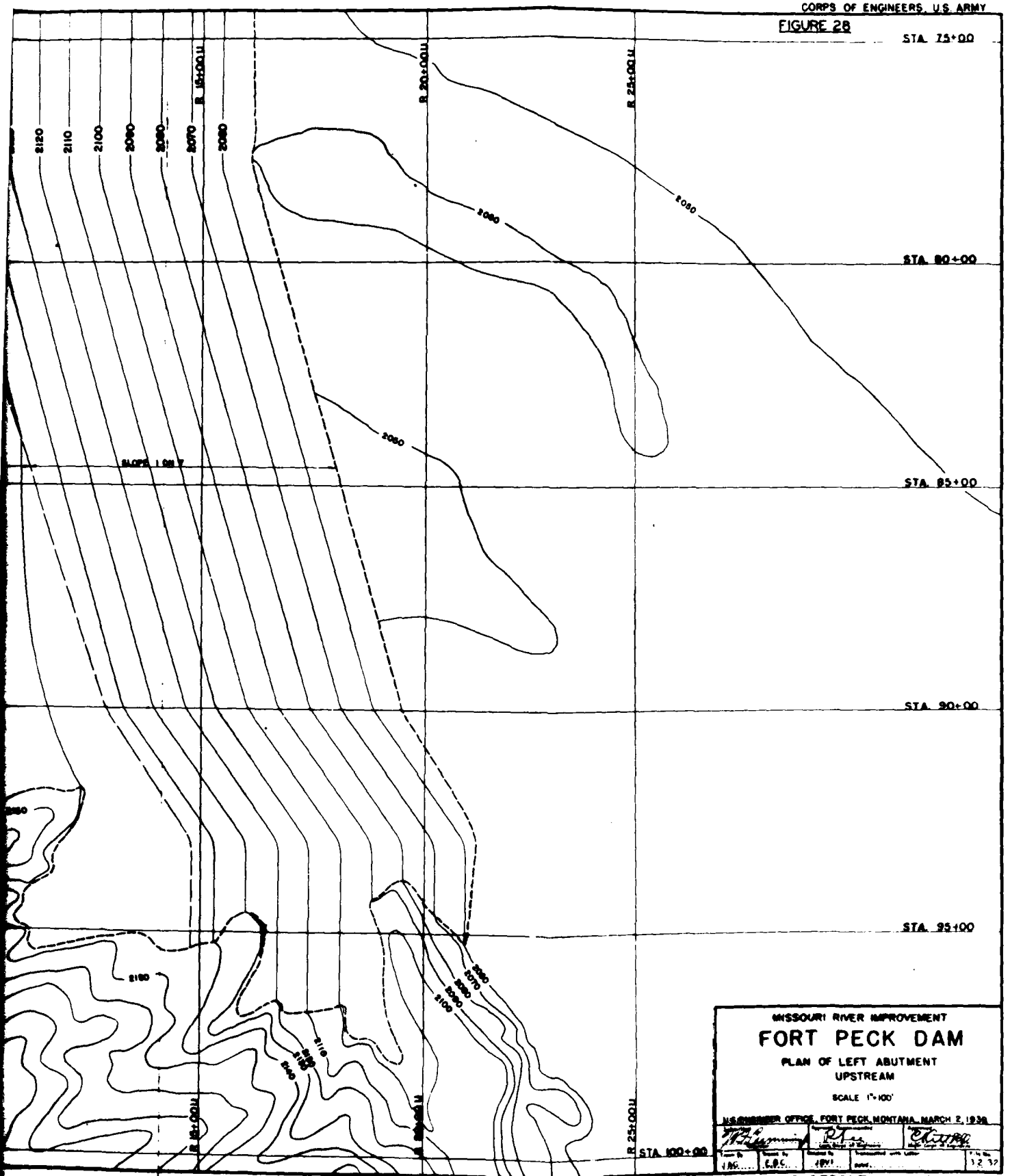

WAR DEPARTMENT
STA. 75+00
STA. 80+00
STA. 85+00
STA. 90+00
STA. 95+00
STA. 98+00
STA. 100+00
AXIS
100'
2270
2260
2250
2240
2230
2220
2210
2200
2190
2180
2170
2160
2150
2140
2130
2120
2110
2100
2090
2080
2070
2060
2212 BERM
2182 BERM
AV. SLOPE 1 ON 3A
SLOPE 1 ON 3A
SLOPE 1 ON 5Q
SLOPE 1 ON 7
CREST EL. 2275.5
2162
2150
2170
2180
2190
2200
2210
2220
R 84+00 U
R 101+00 U
R 118+00 U
FORT PE

FIGURE 28



MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

PLAN OF LEFT ABUTMENT
UPSTREAM

SCALE 1"=100'

U.S. ENGINEER OFFICE, FORT PECK, MONTANA, MARCH 2, 1938

2

WAR DEPARTMENT

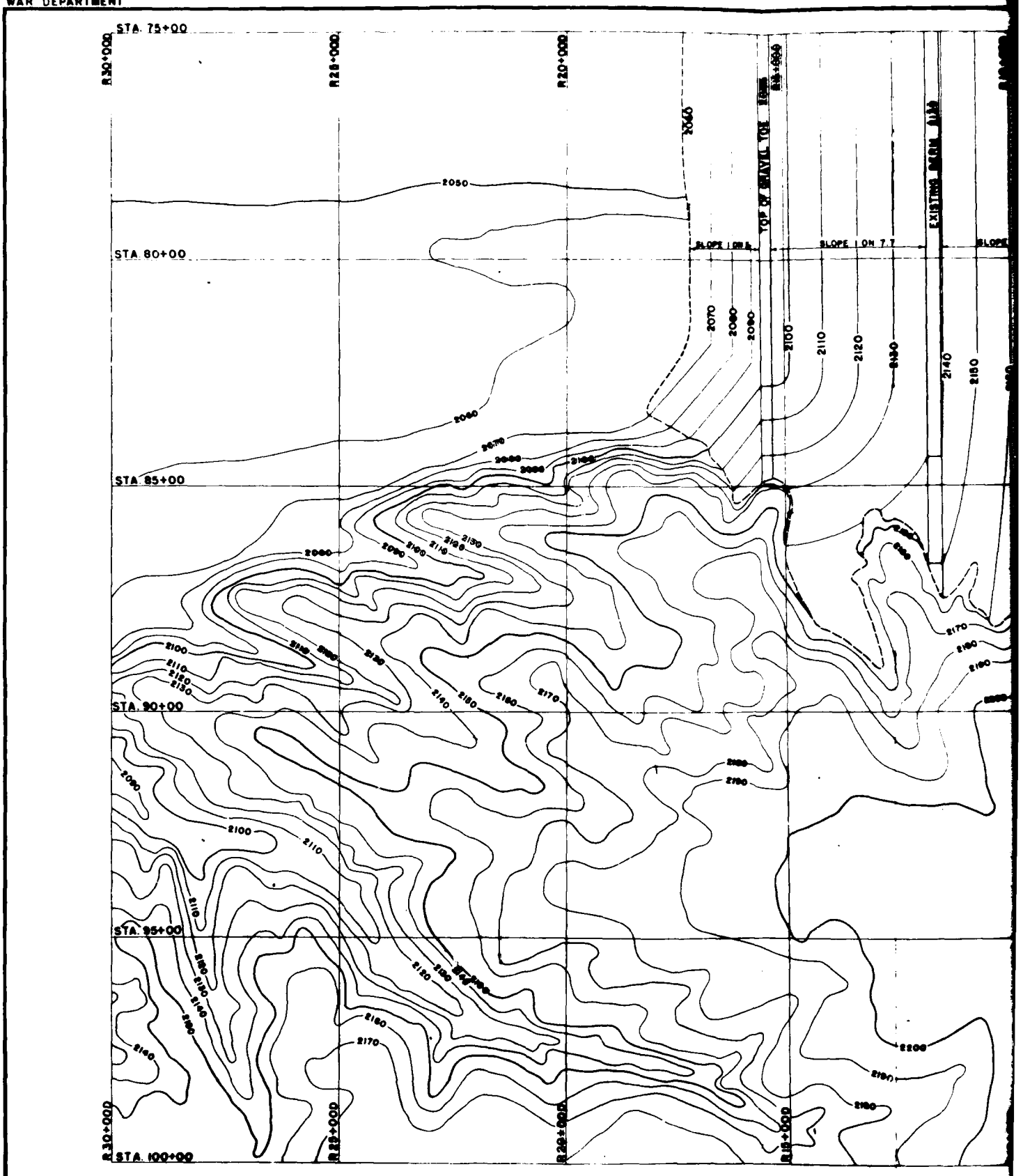
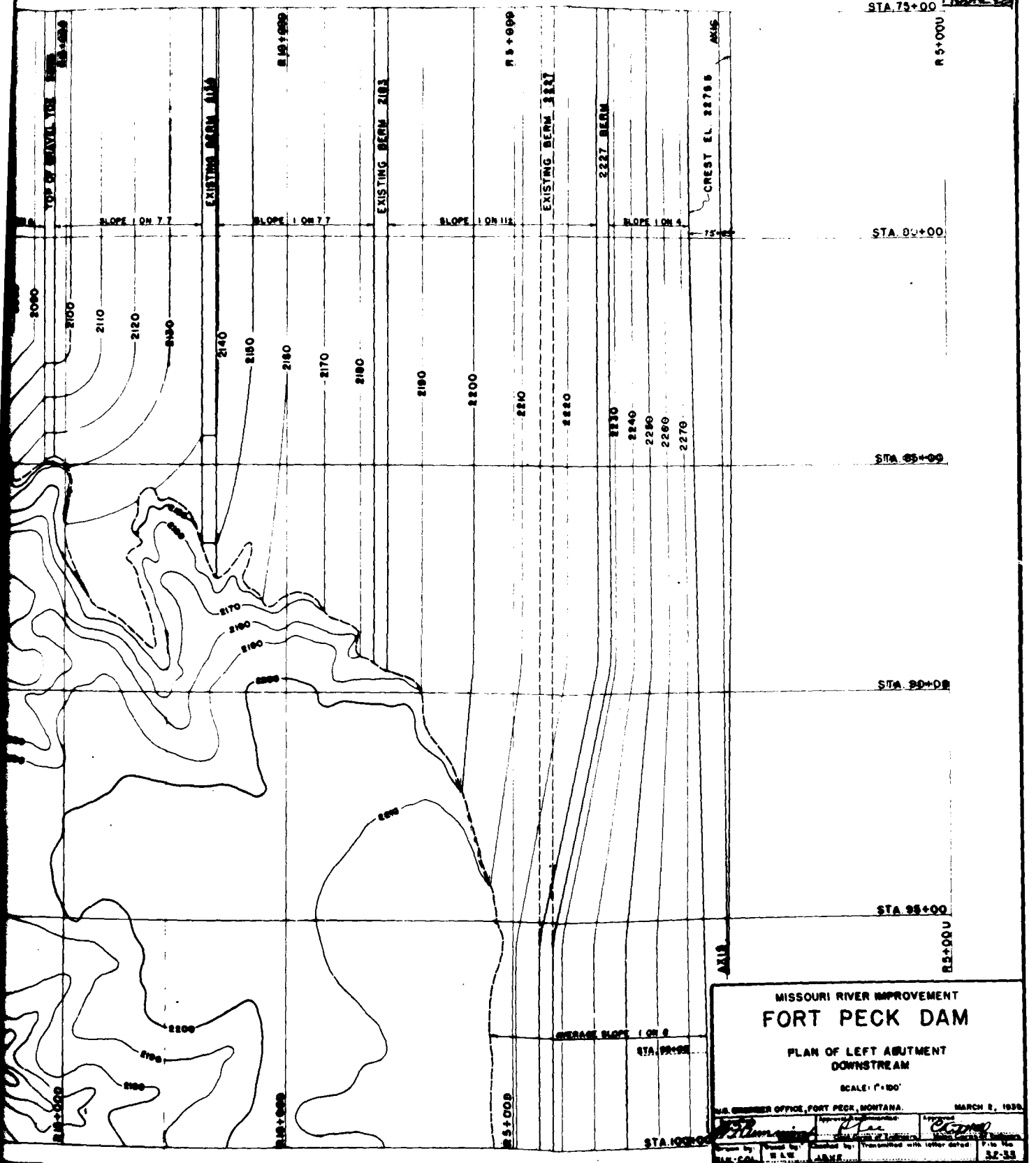


FIGURE 29



MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

PLAN OF LEFT ABUTMENT
DOWNSTREAM

SCALE: 1"=100'

U.S. ENGINEER OFFICE, FORT PECK, MONTANA. MARCH 8, 1938.

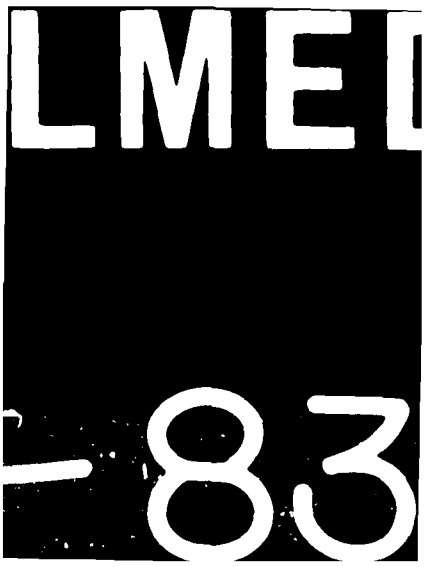
Drawn by	Traced by	Checked by	Approved
[illegible]	W.L.W.	ARMK	[illegible]

Transmitted with letter dated: File No. 32-33

[illegible] CRITERIA AND PERFORMANCE REPORT PLATE 5-48

6 P O — 180810

2


LME
83